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Oberdorfer et al.

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(45) **Date of Patent: Apr. 30, 2024**

(54) **SINGLE AIR DISC BRAKE TAPPET WITH FEATURES THAT MIMIC MULTIPLE TAPPETS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Jun. 23, 2023**

(51) **Int. Cl.**
F16D 65/095 (2006.01)

(52) **U.S. Cl.**
CPC ***F16D 65/095*** (2013.01)

(58) **Field of Classification Search**
CPC F16D 65/095; F16D 65/04; F16D 65/067; F16D 65/09
See application file for complete search history.

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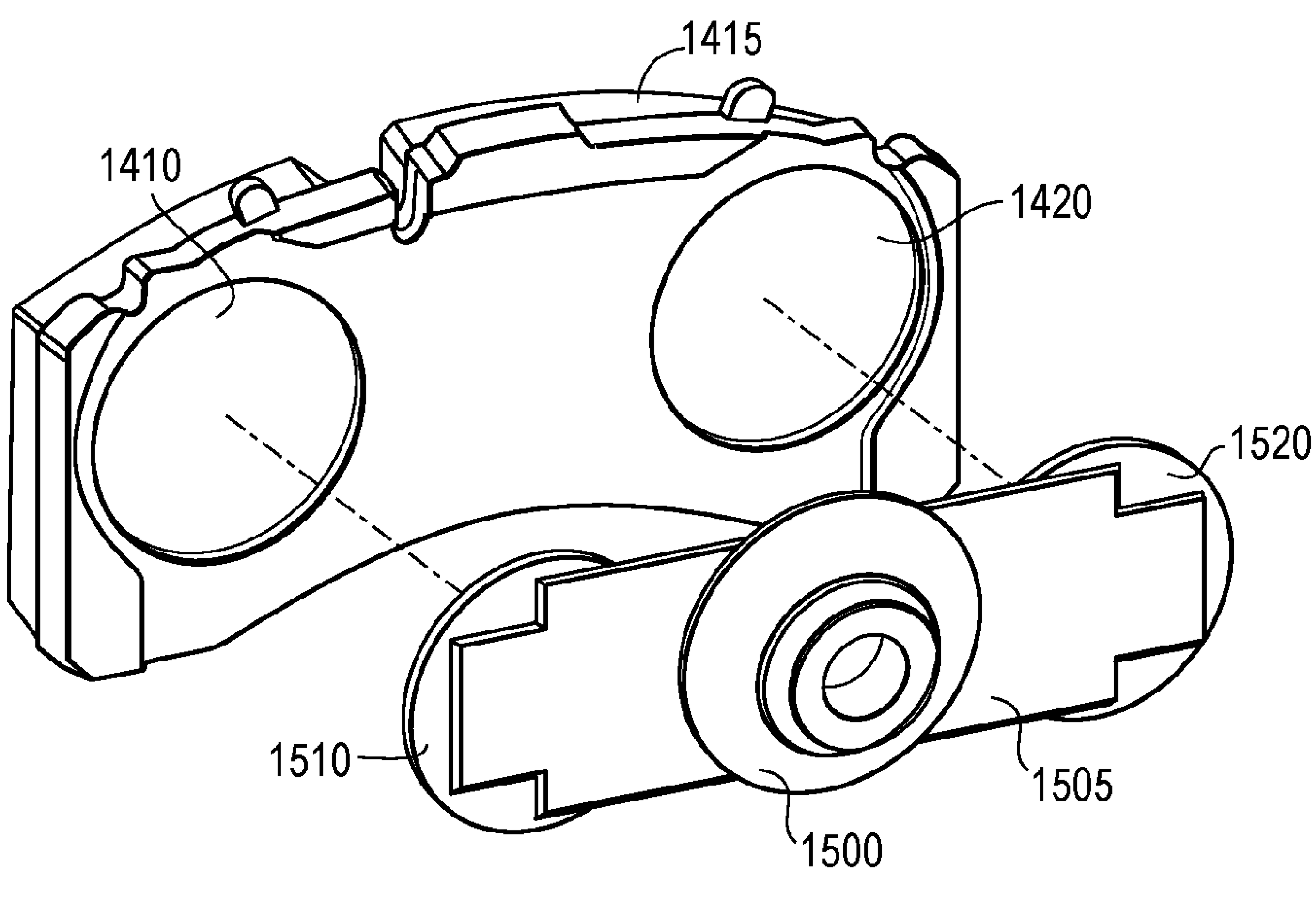
Primary Examiner — Pamela Rodriguez
(74) *Attorney, Agent, or Firm* — Crowell & Moring LLP

(57) **ABSTRACT**

The following embodiments relate to a single air disc brake tappet with features that mimic multiple tappets. In one embodiment, an air disc brake tappet is provided comprising: a support member; and a plate coupled with support member, wherein the plate comprises a plurality of raised features that mimic a plurality of air disc brake tappets. In another embodiment, an air disc brake pad assembly is provided comprising: a friction material; and a backing plate coupled with the friction material, wherein the backing plate comprises at least one recess shaped and positioned to receive a plurality of raised features of an air disc brake tappet, wherein the plurality of raised features mimics a plurality of air disc brake tappets. Other embodiments are provided.

17 Claims, 26 Drawing Sheets



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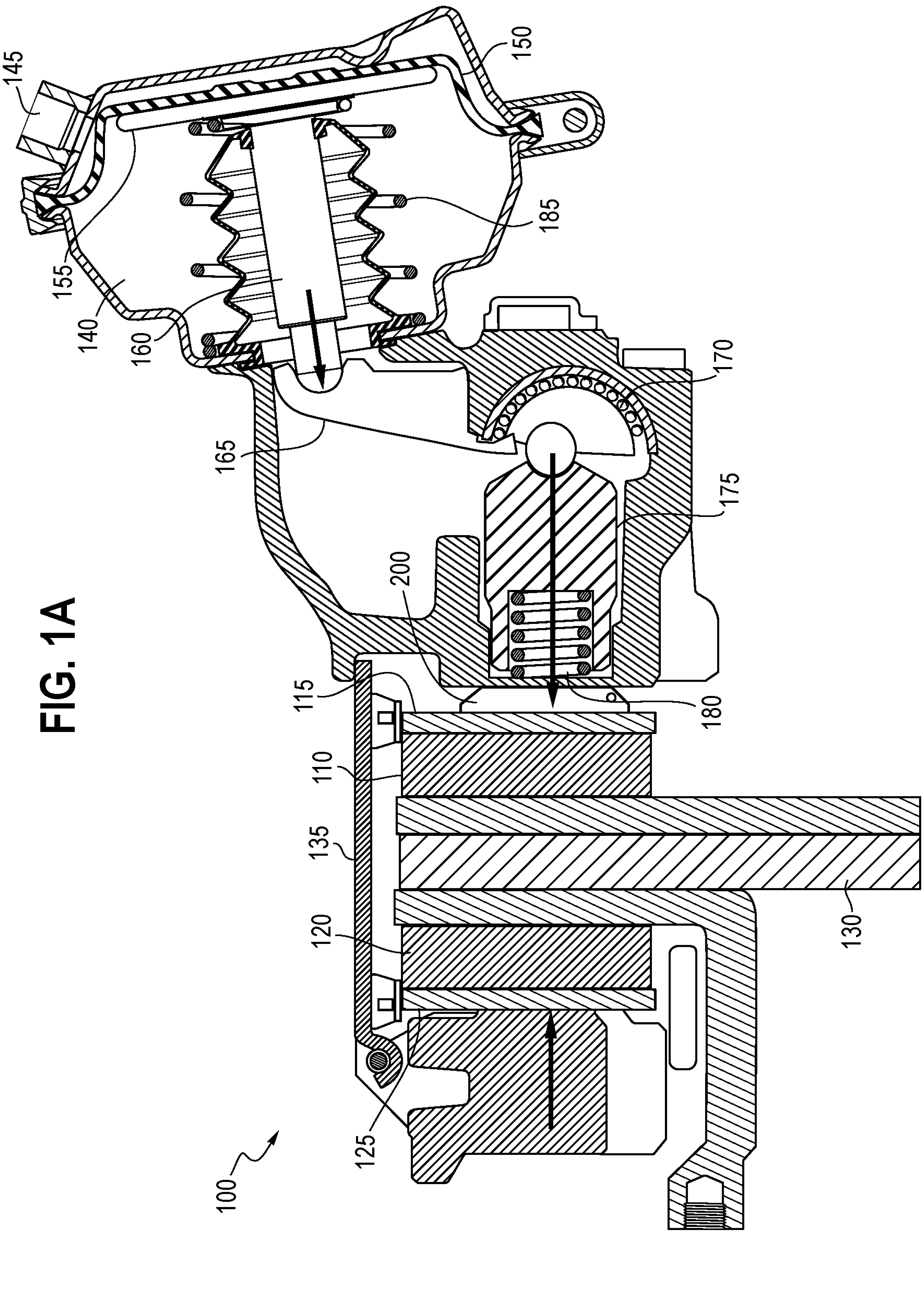
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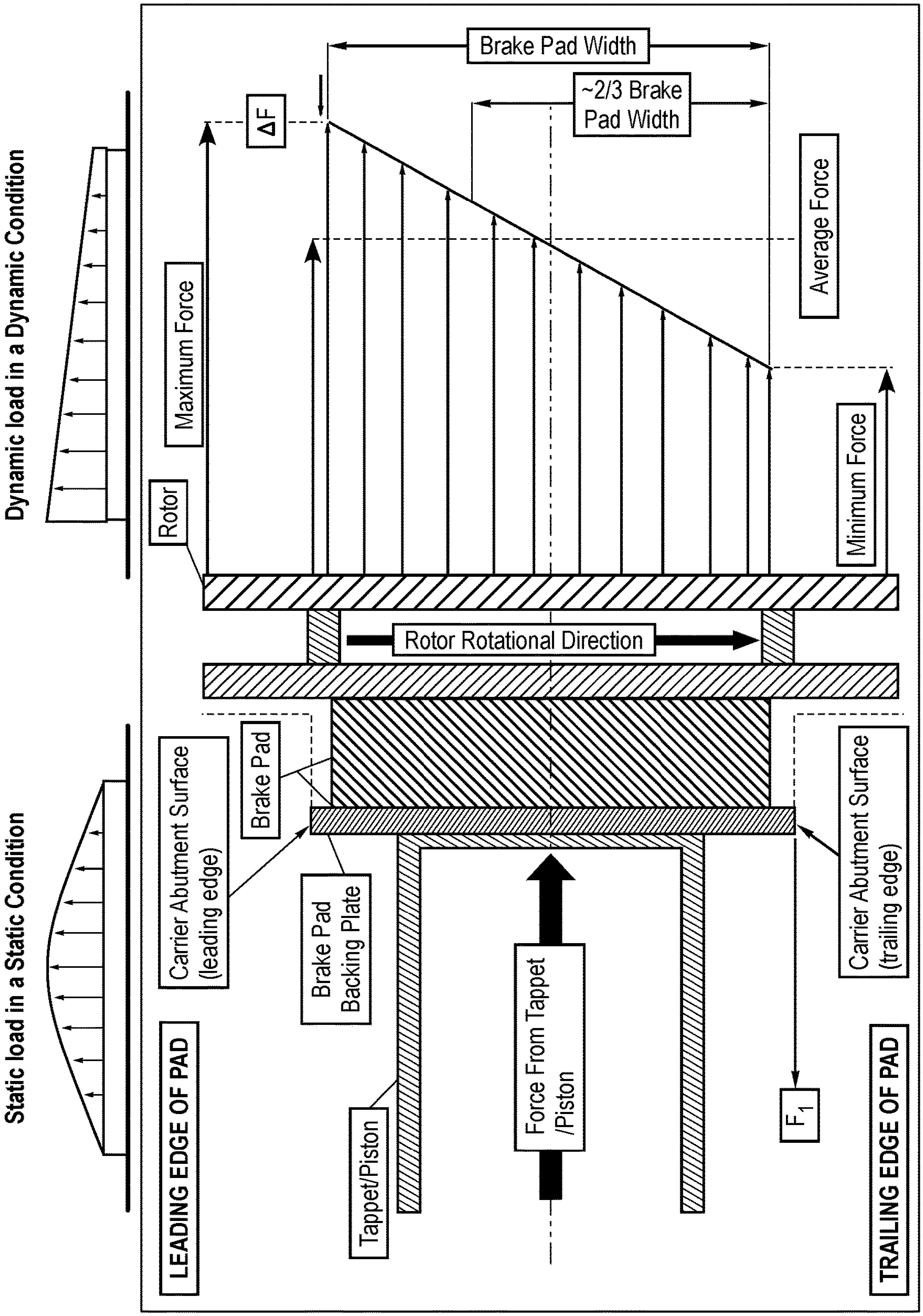
FIG. 1A

FIG. 1B



Dynamic load in a Dynamic Condition
Static load in a Static Condition
LEADING EDGE OF PAD
TRAILING EDGE OF PAD
Brake Pad Width
~2/3 Brake Pad Width
ΔF
Maximum Force
Average Force
Minimum Force
Rotor
Rotor Rotational Direction
Carrier Abutment Surface (leading edge)
Carrier Abutment Surface (trailing edge)
Brake Pad
Brake Pad Backing Plate
Tappet/Piston
Force From Tappet /Piston
F1

FIG. 2A

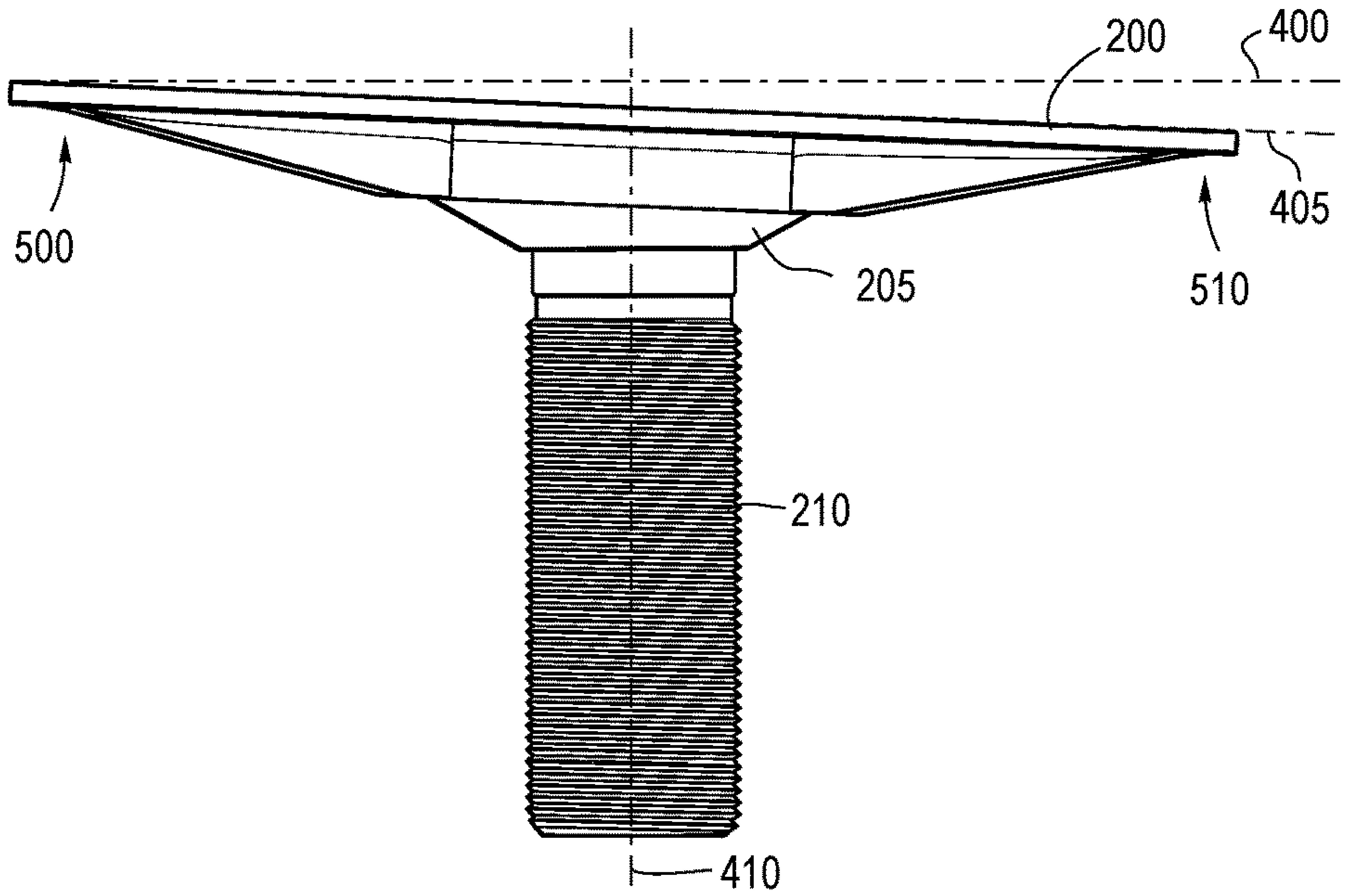
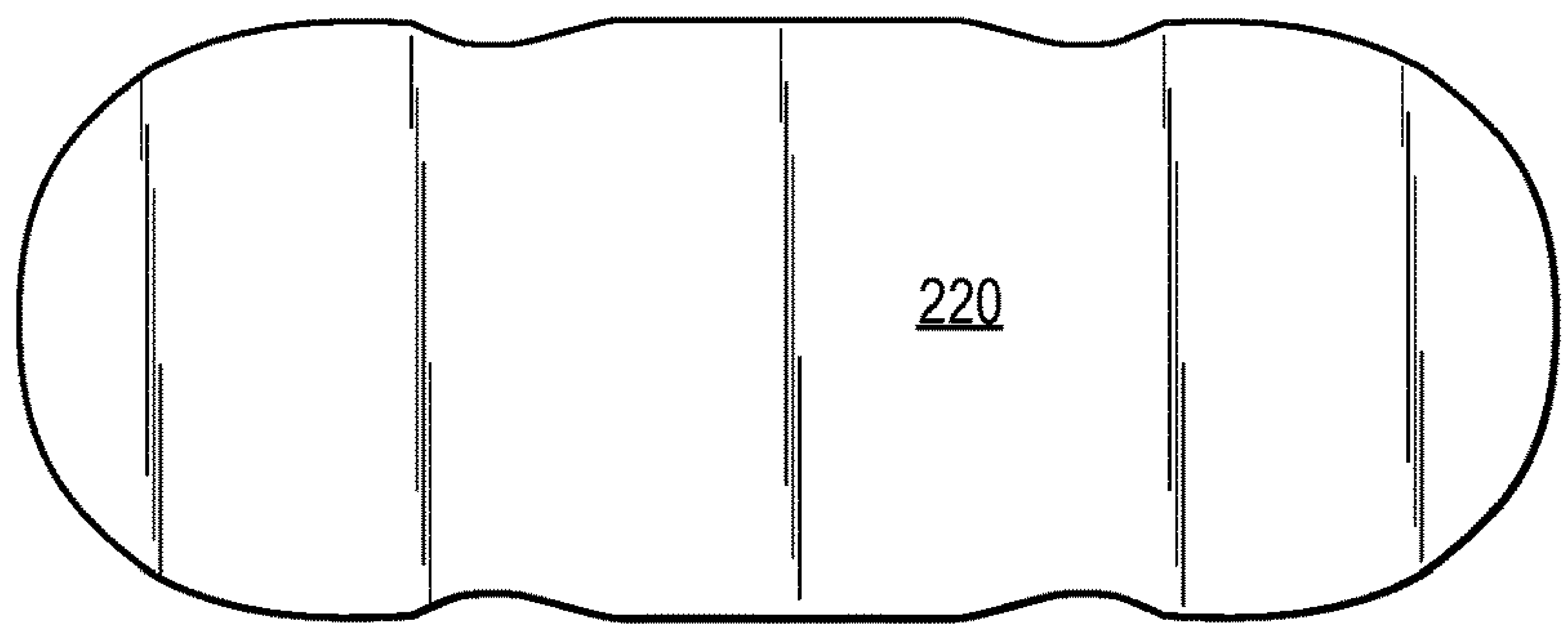


FIG. 2B



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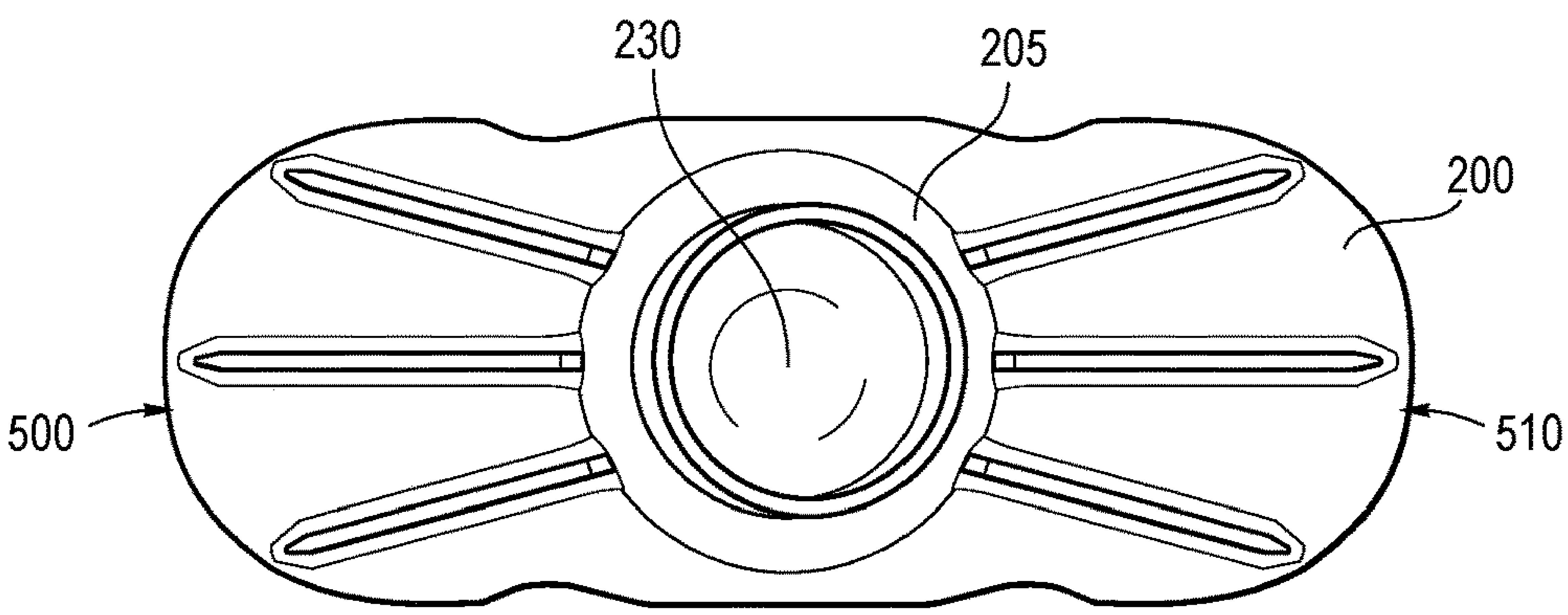


FIG. 3A

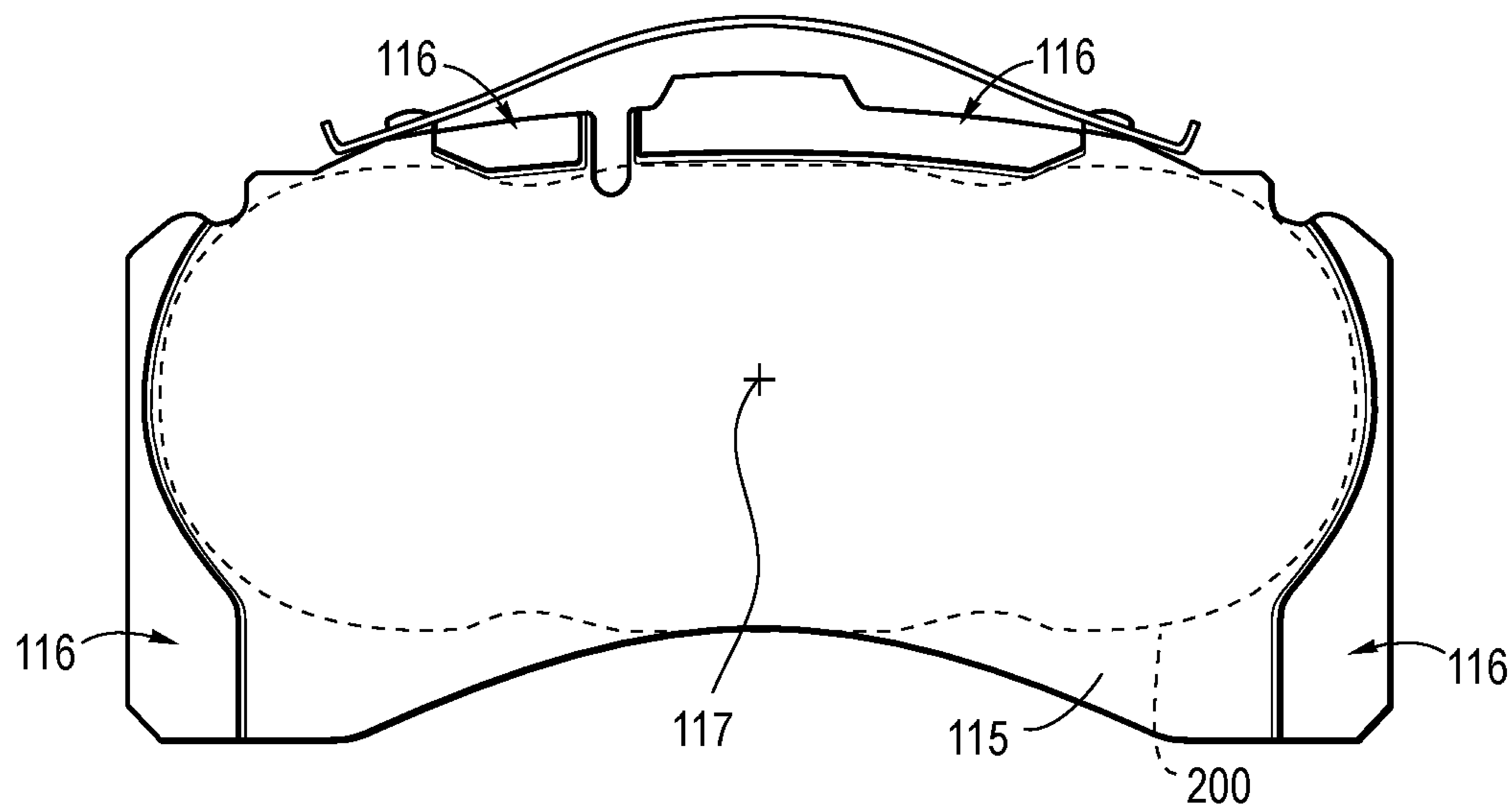


FIG. 3B

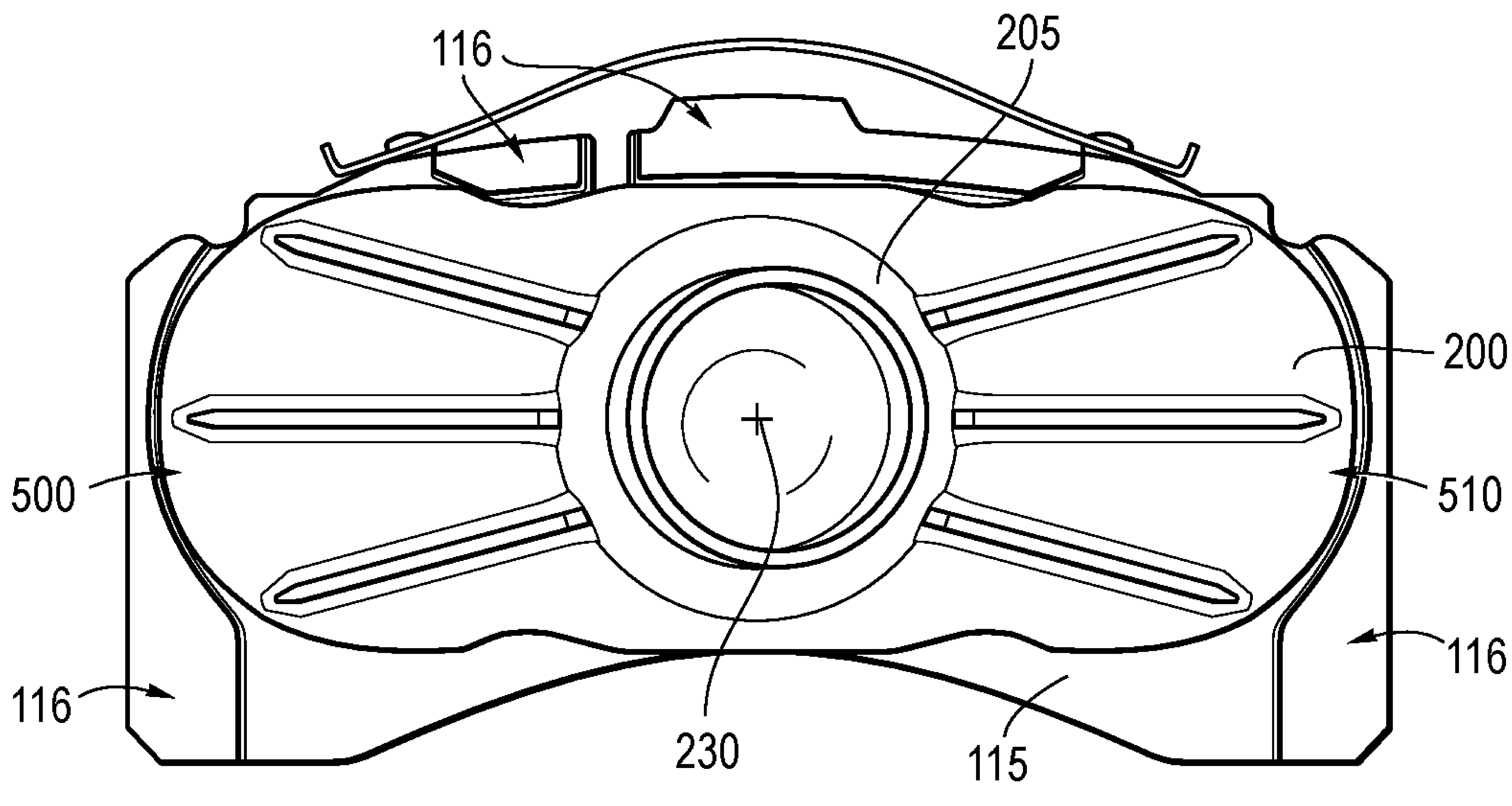


FIG. 4A

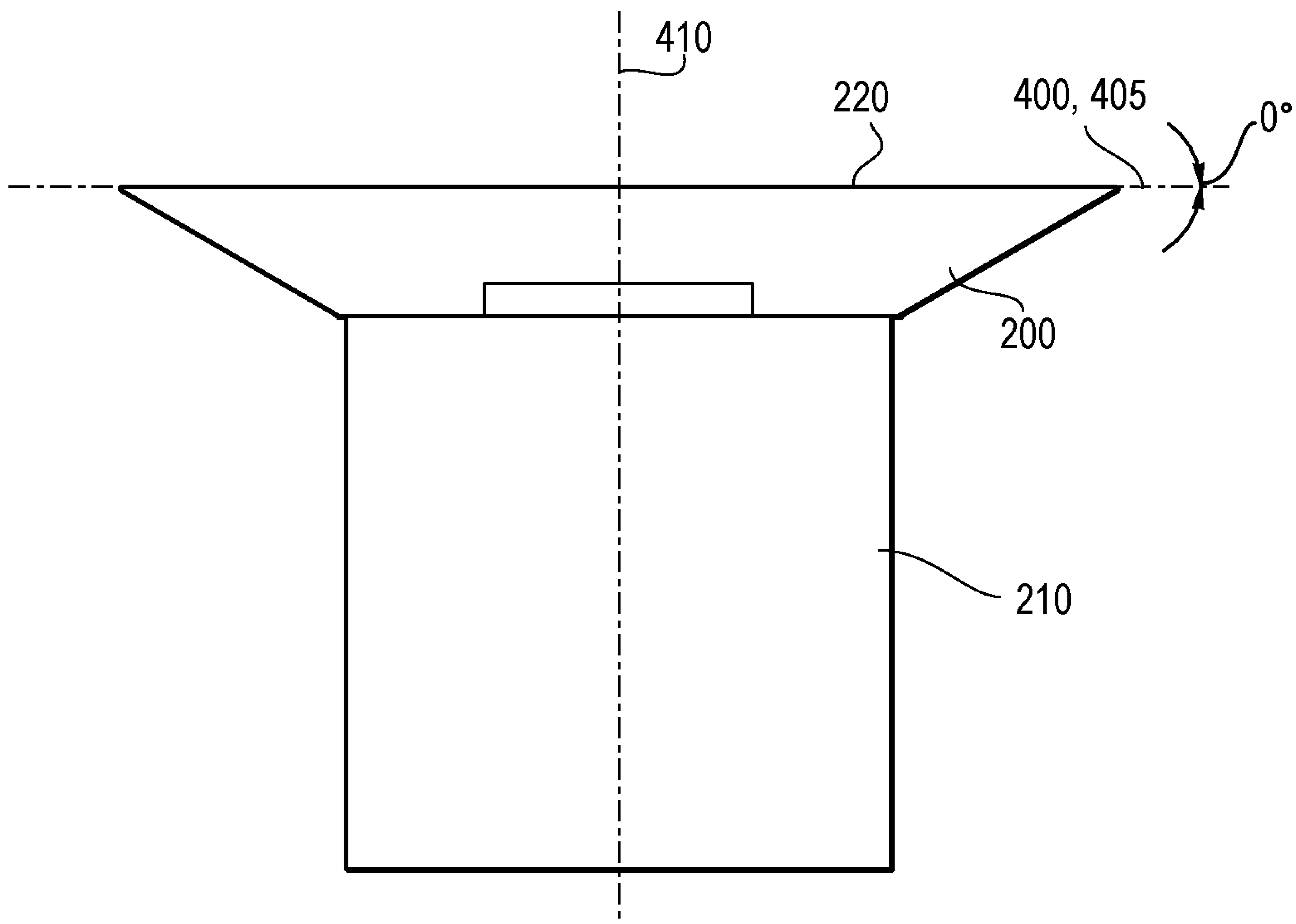
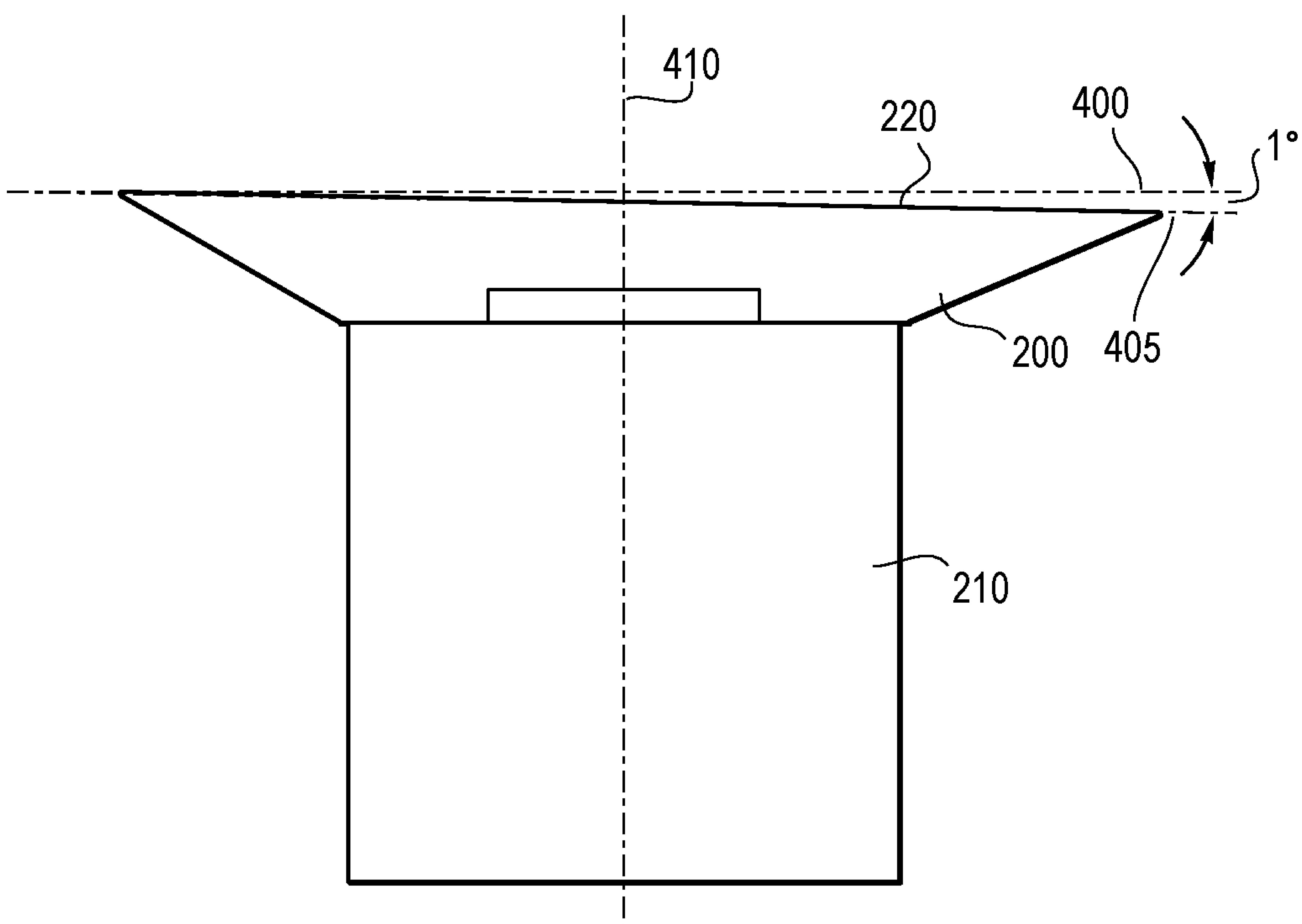


FIG. 4B



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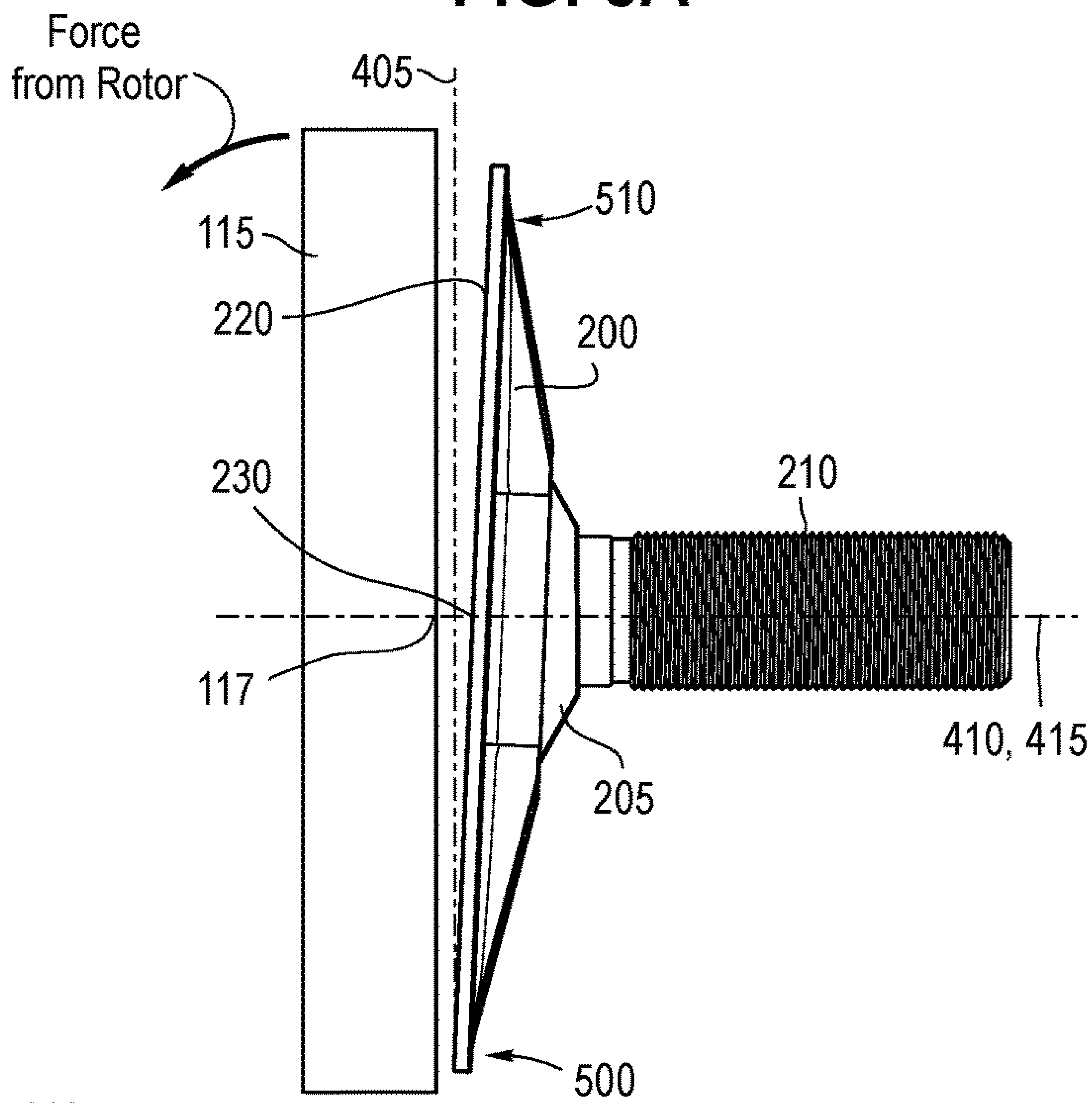


FIG. 5B

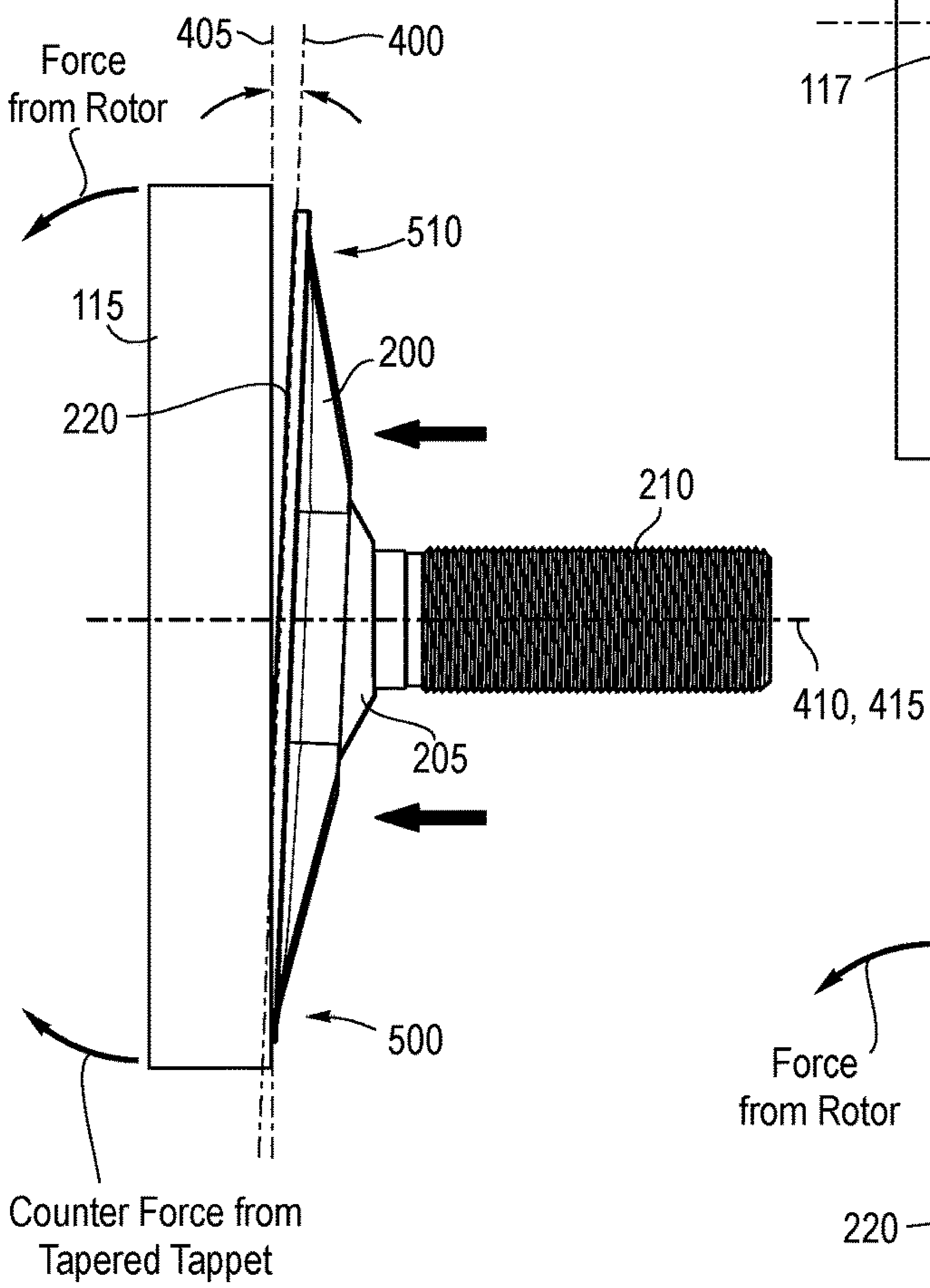


FIG. 5C

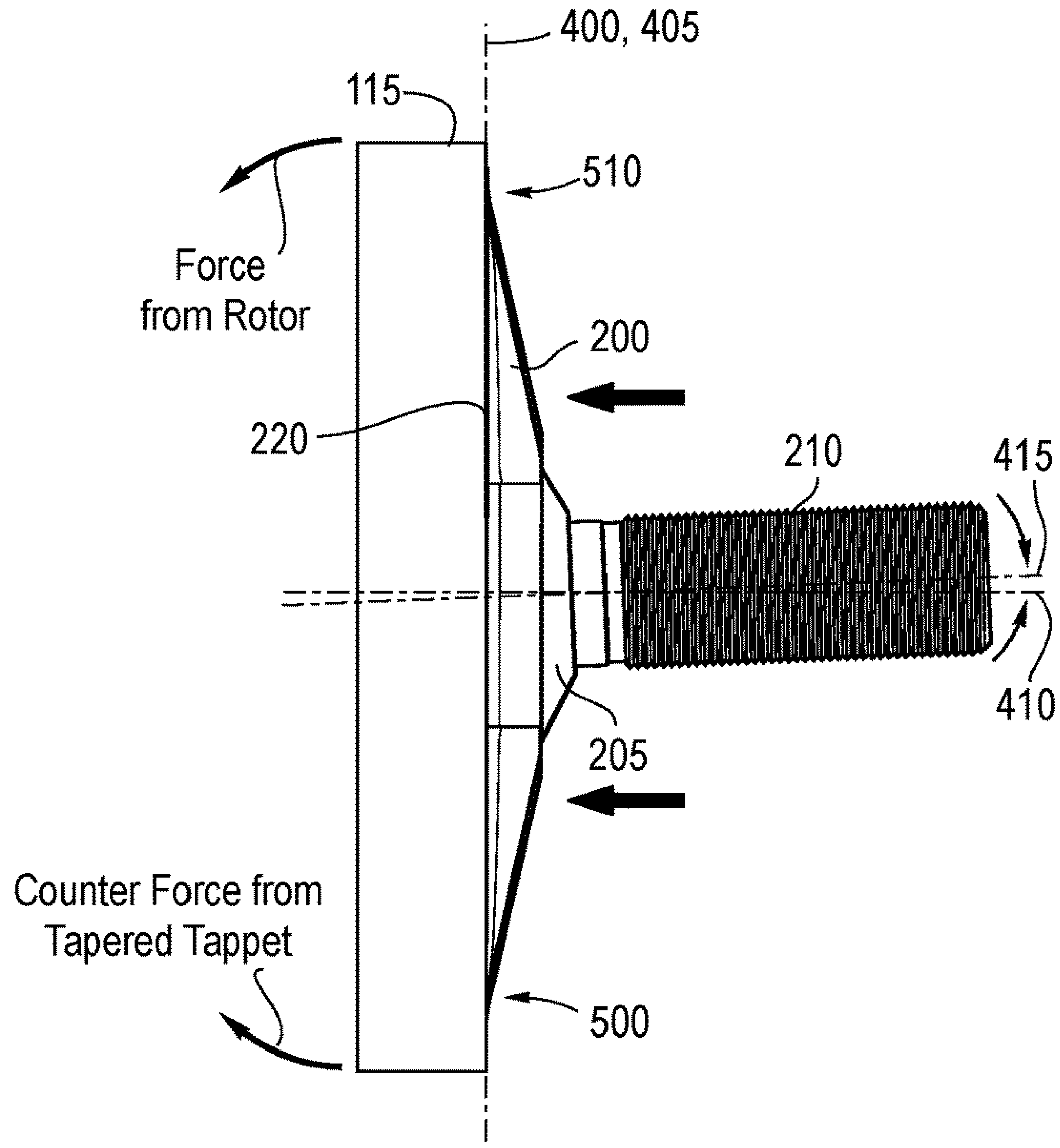
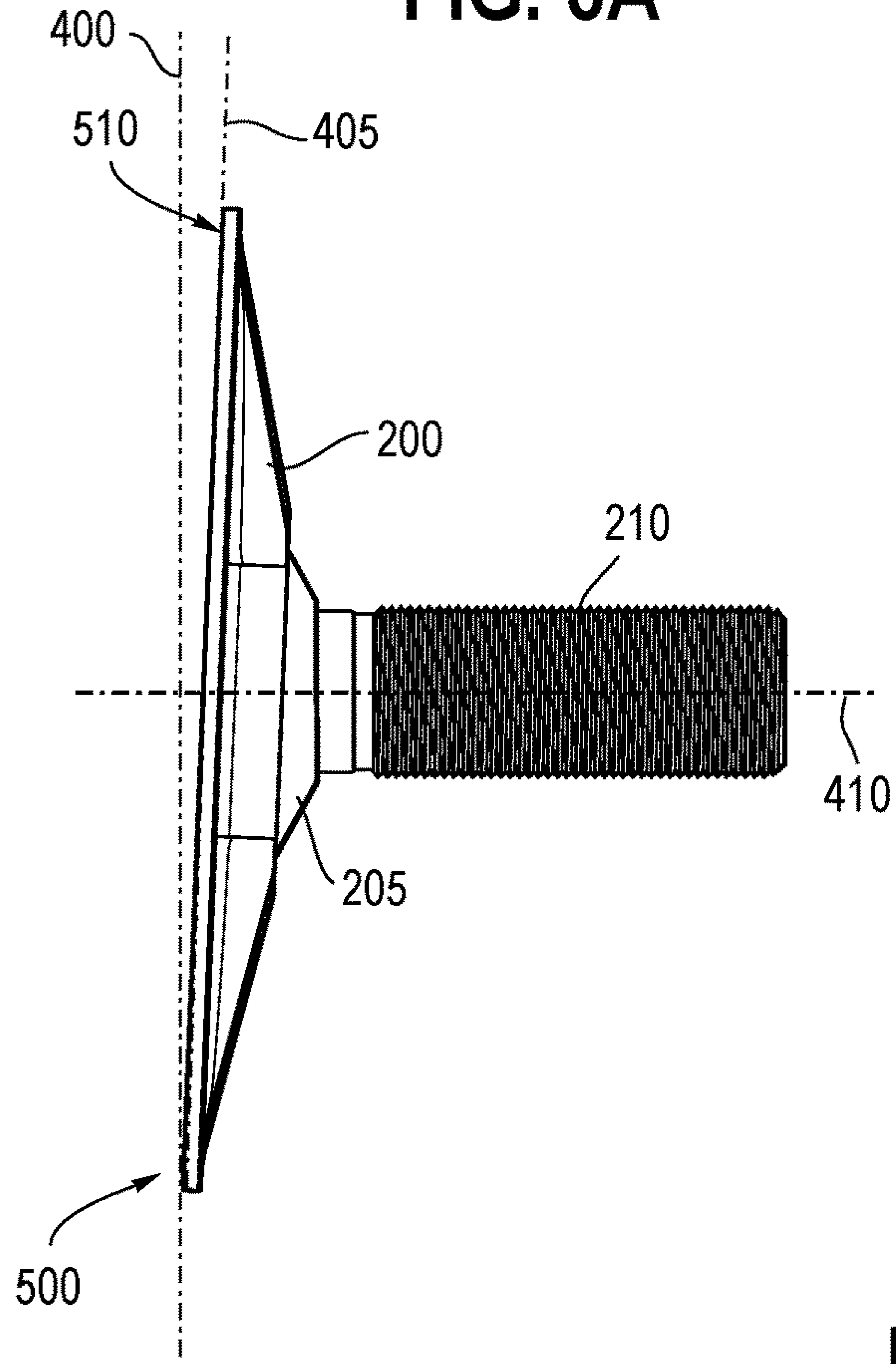


FIG. 6A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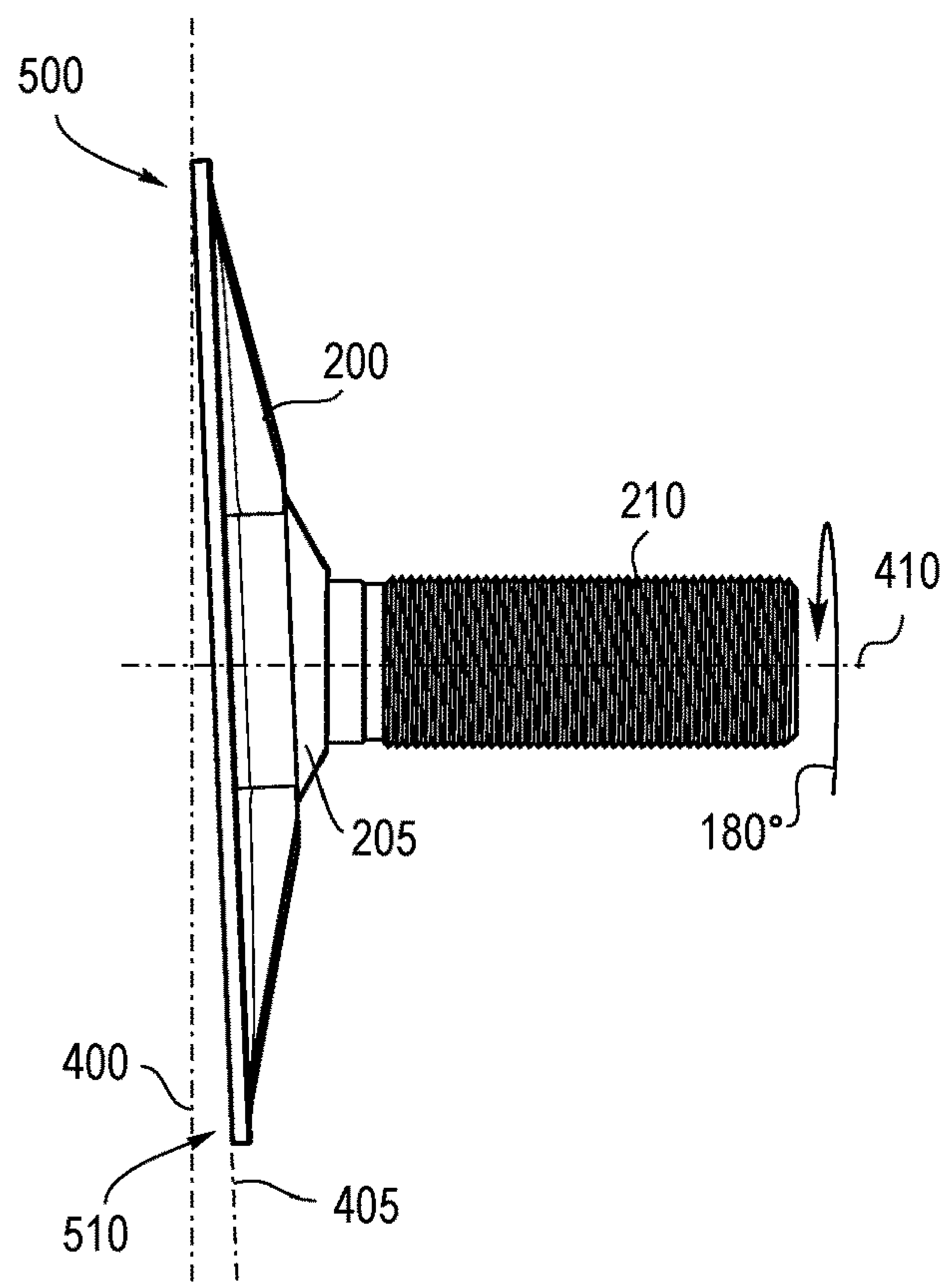
410
205
500

FIG. 6B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180°
400
510
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FIG. 7A

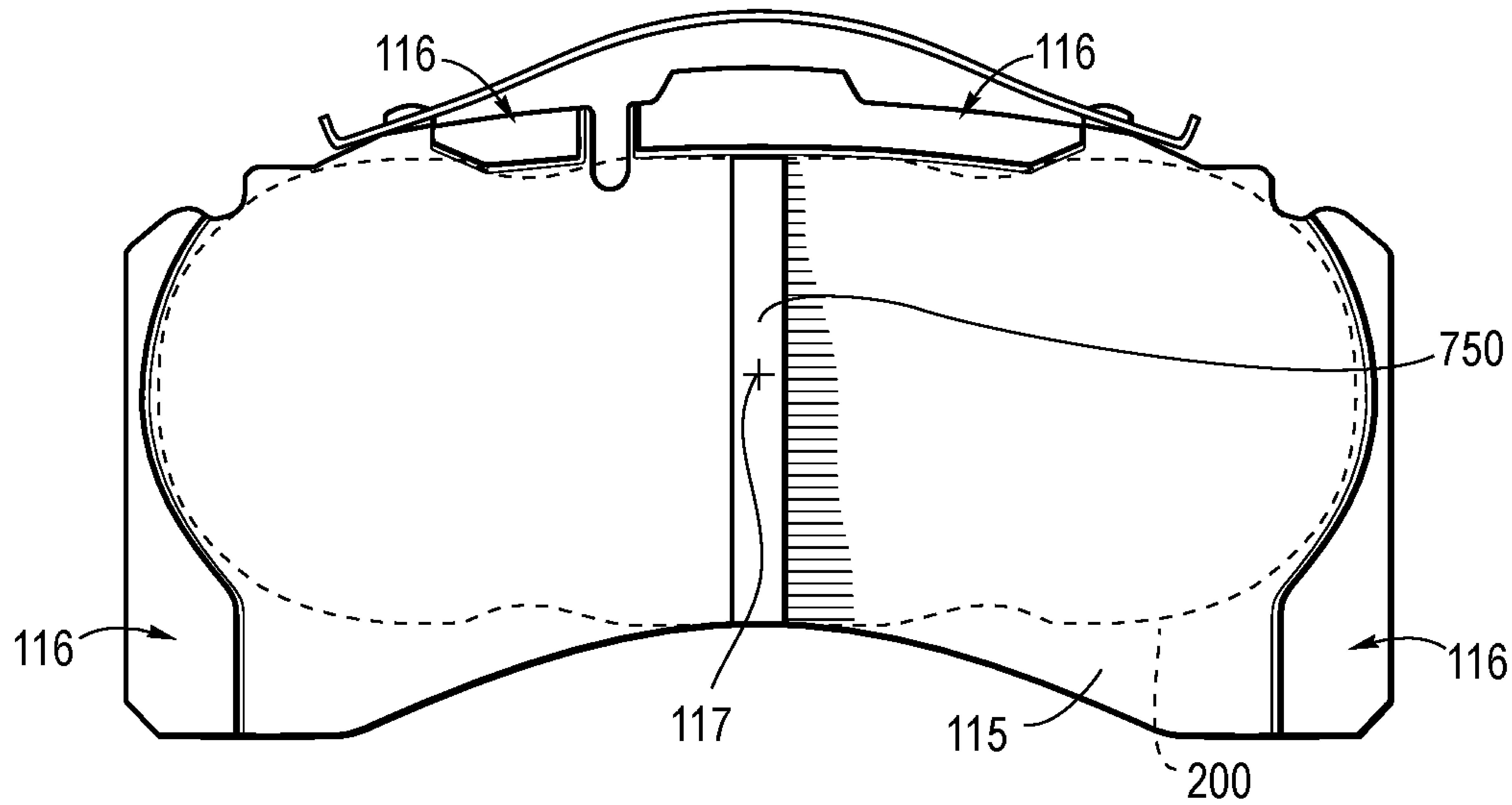


FIG. 7B

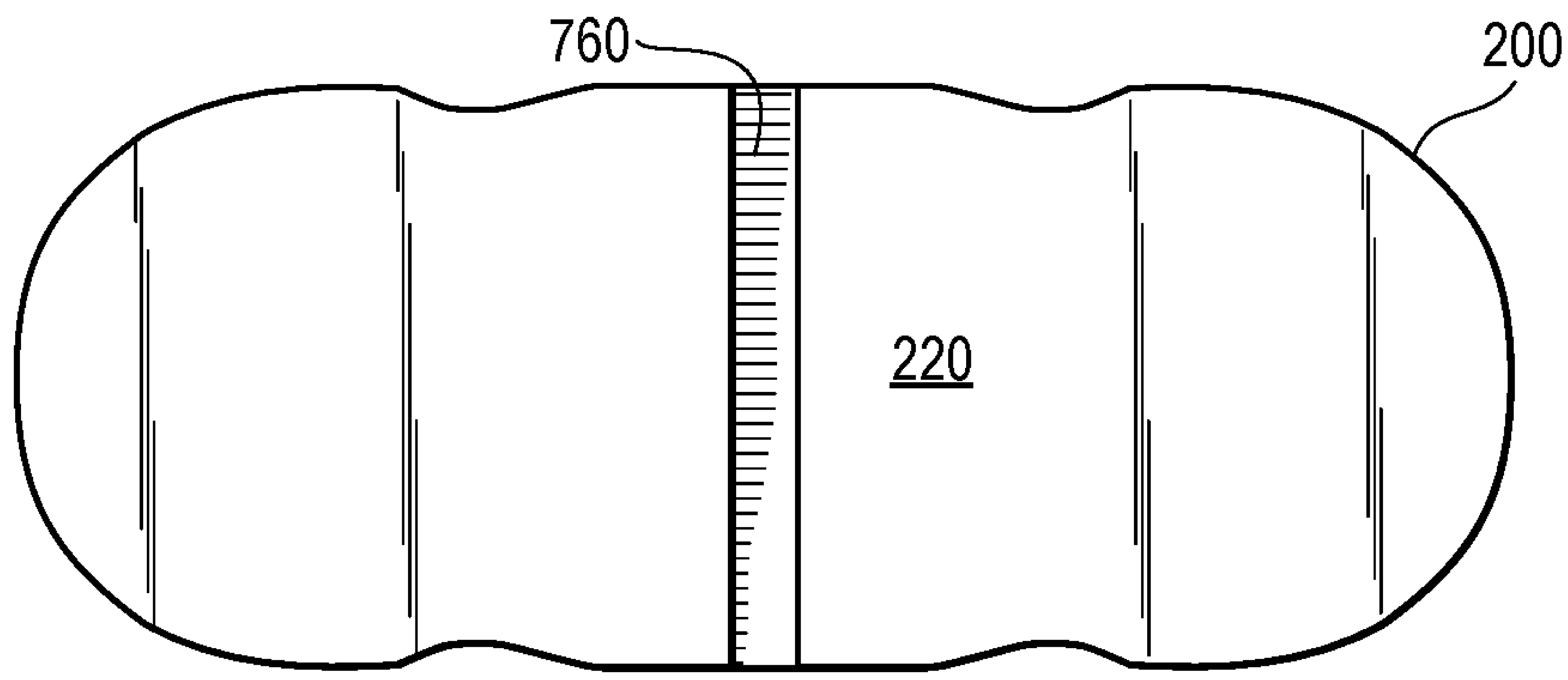


FIG. 8A

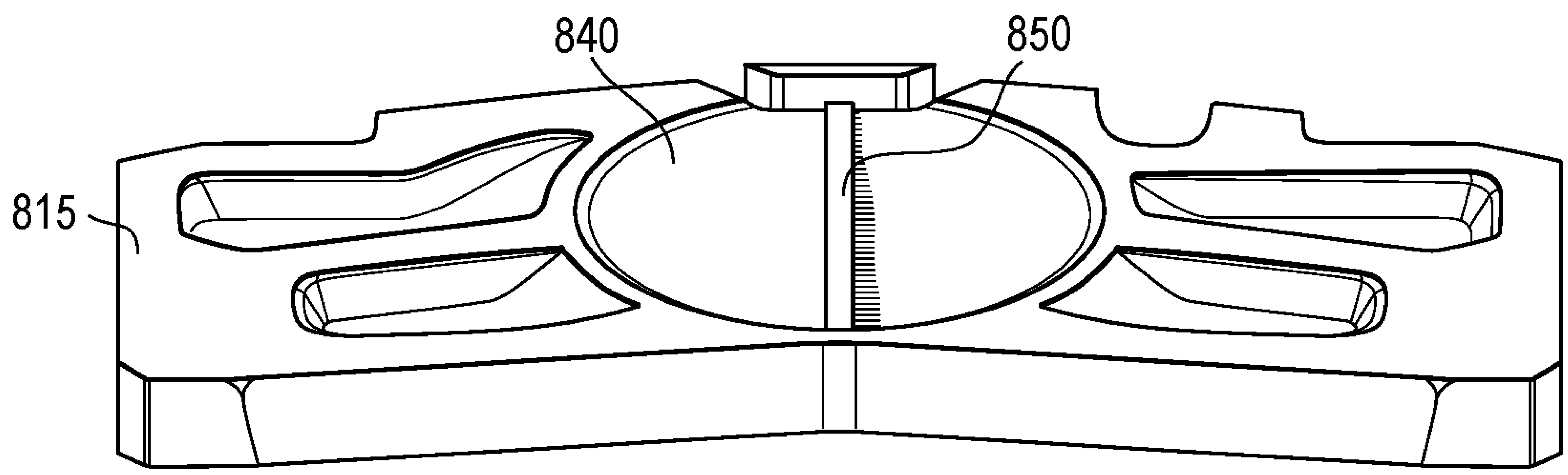


FIG. 8B

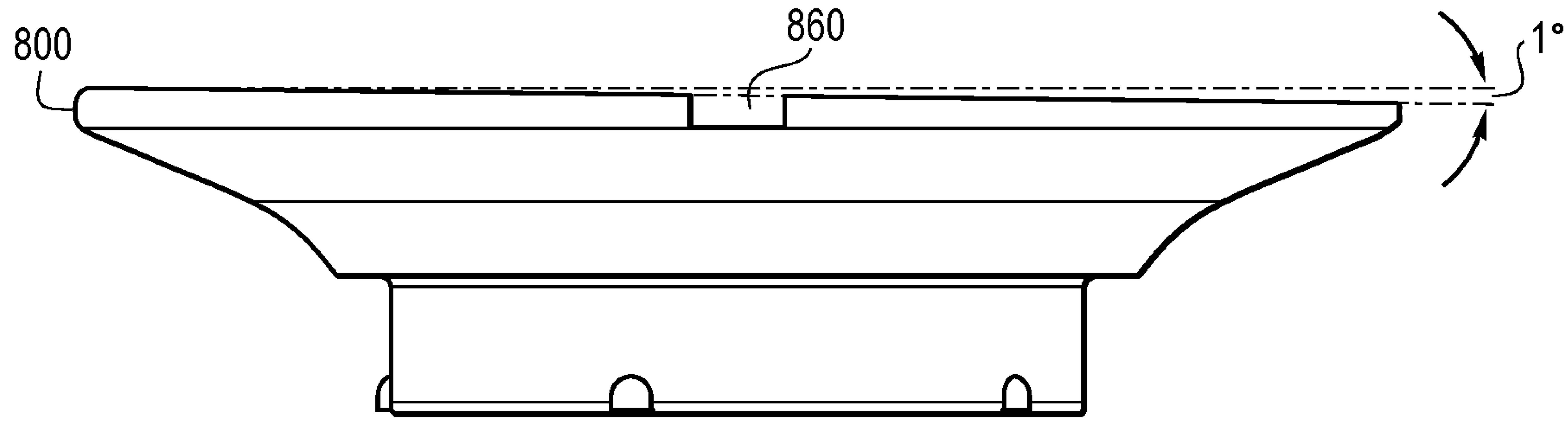


FIG. 8C

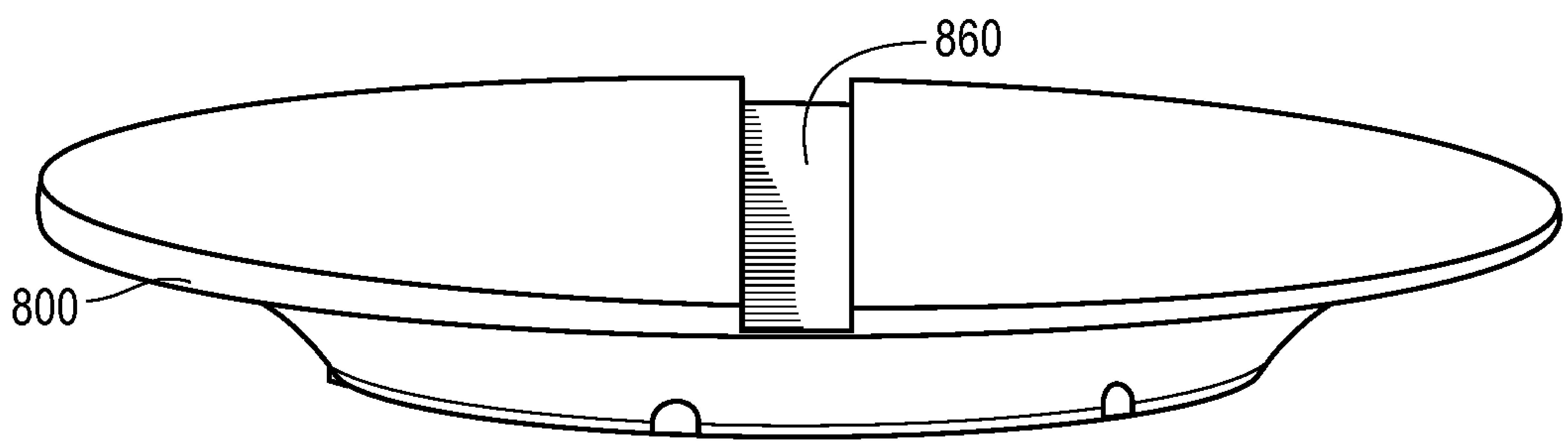
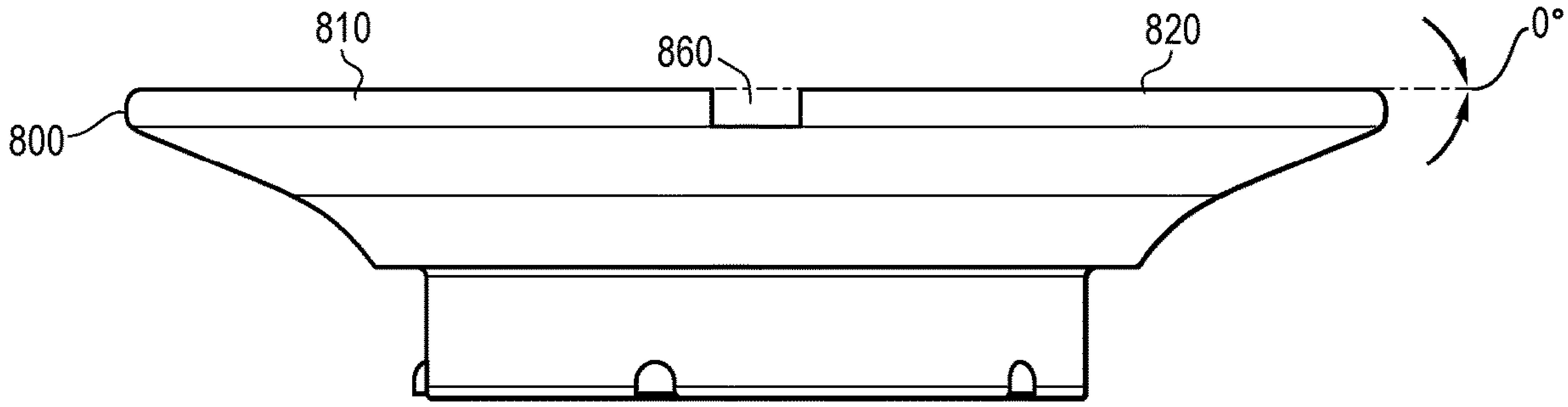


FIG. 8D



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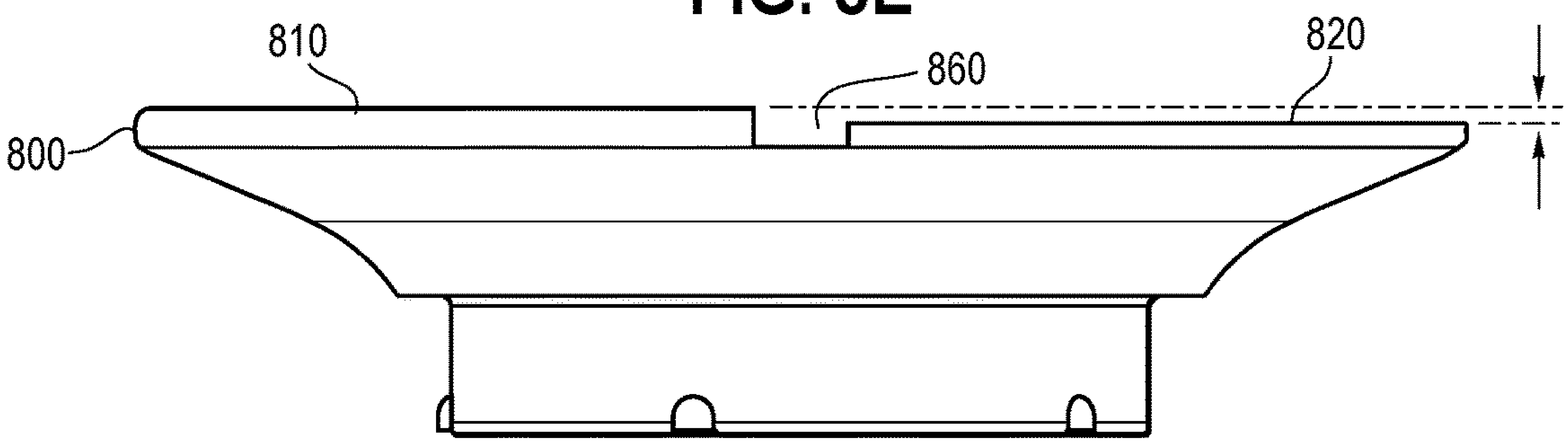

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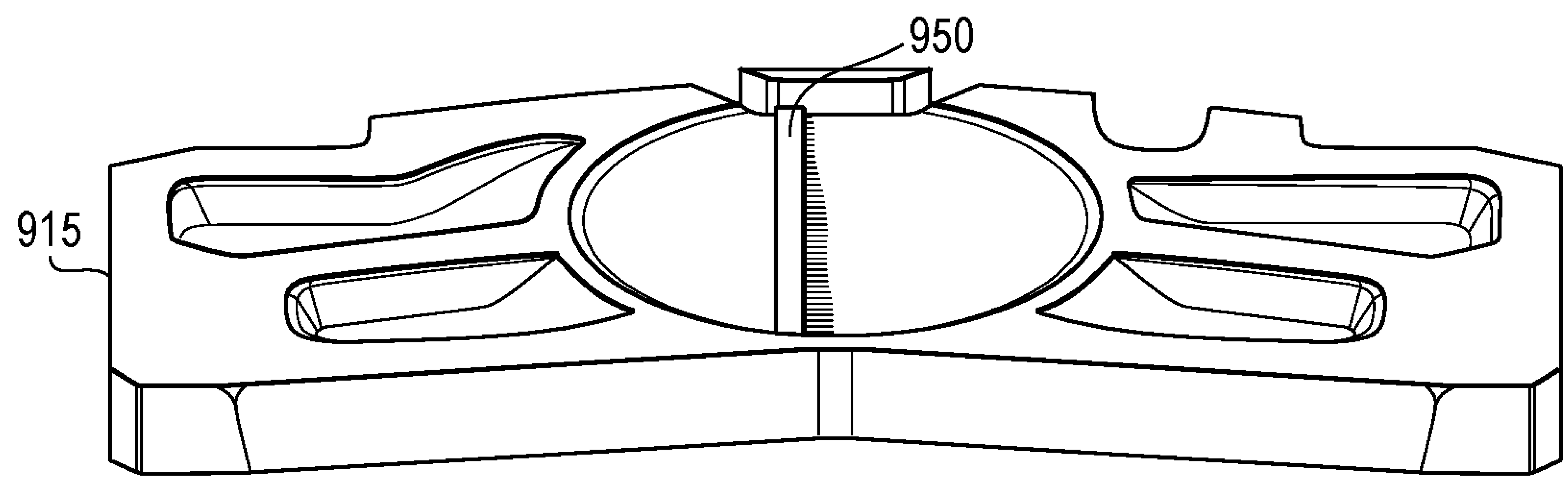

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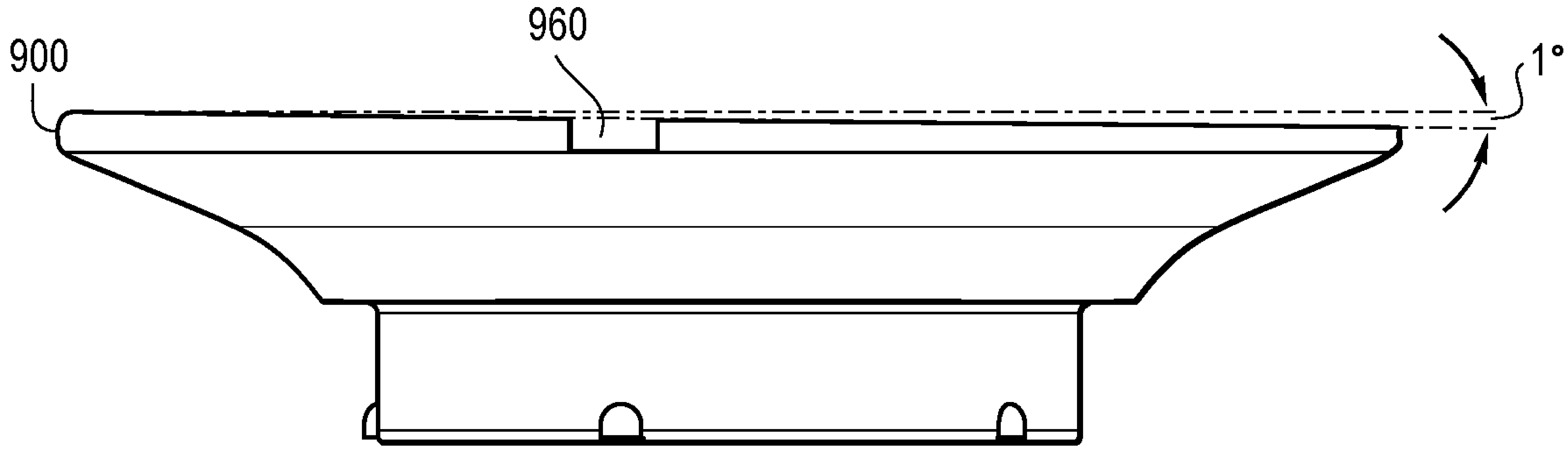

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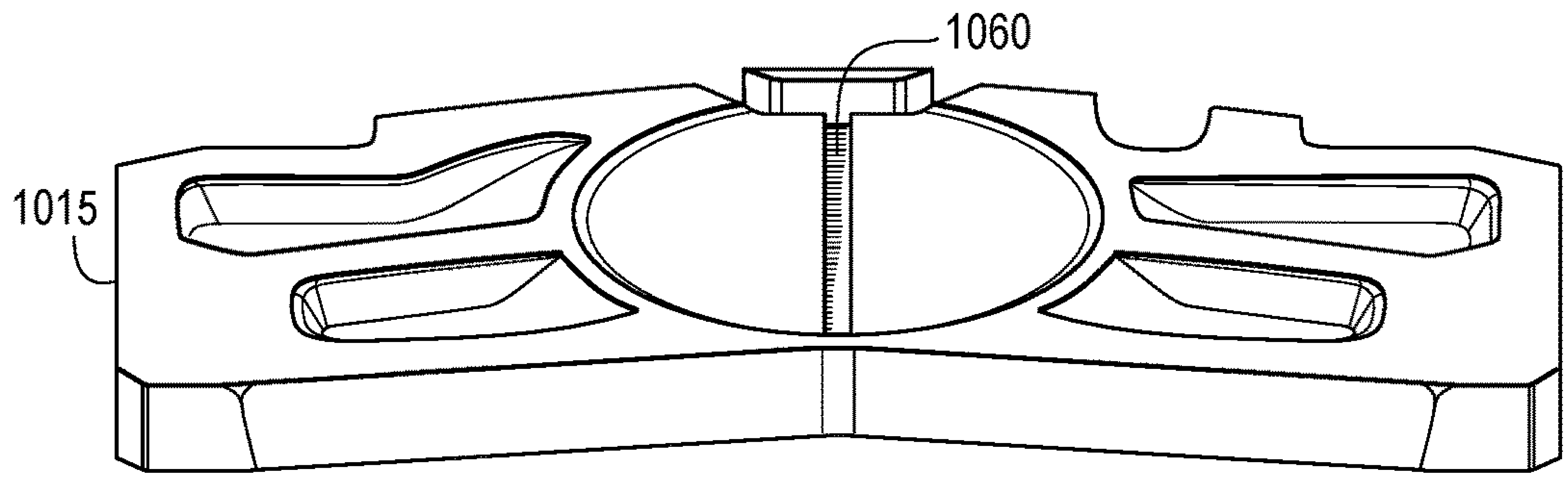
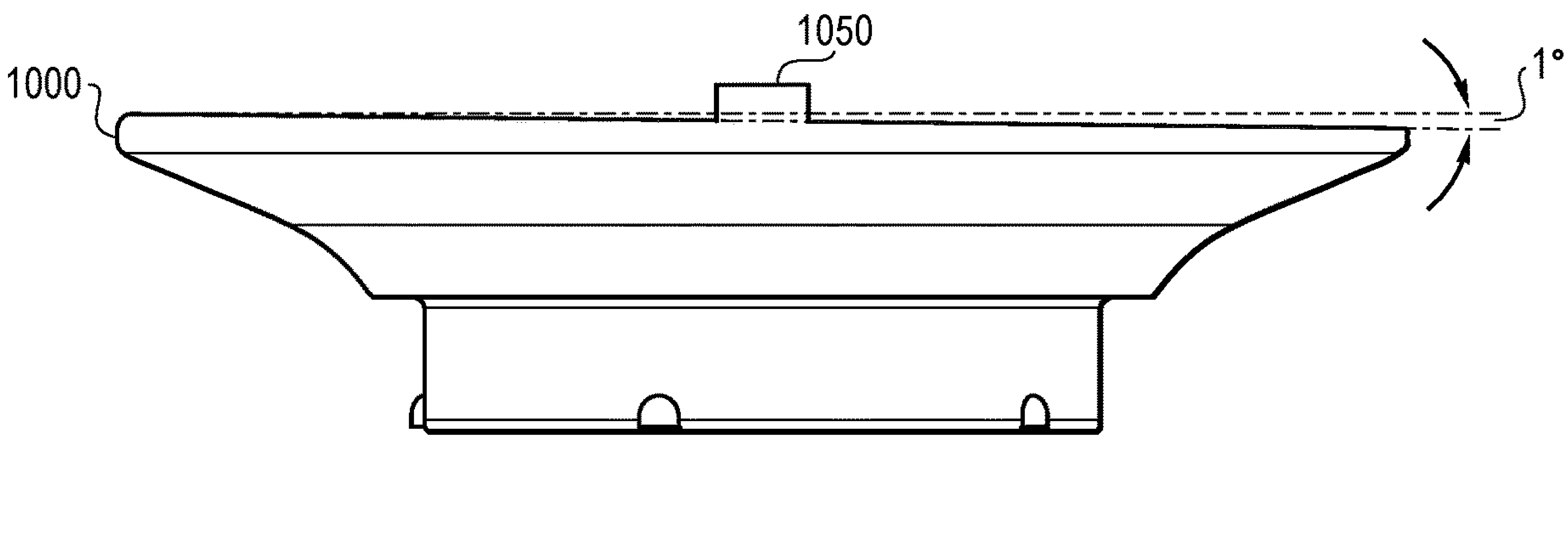


FIG. 10B



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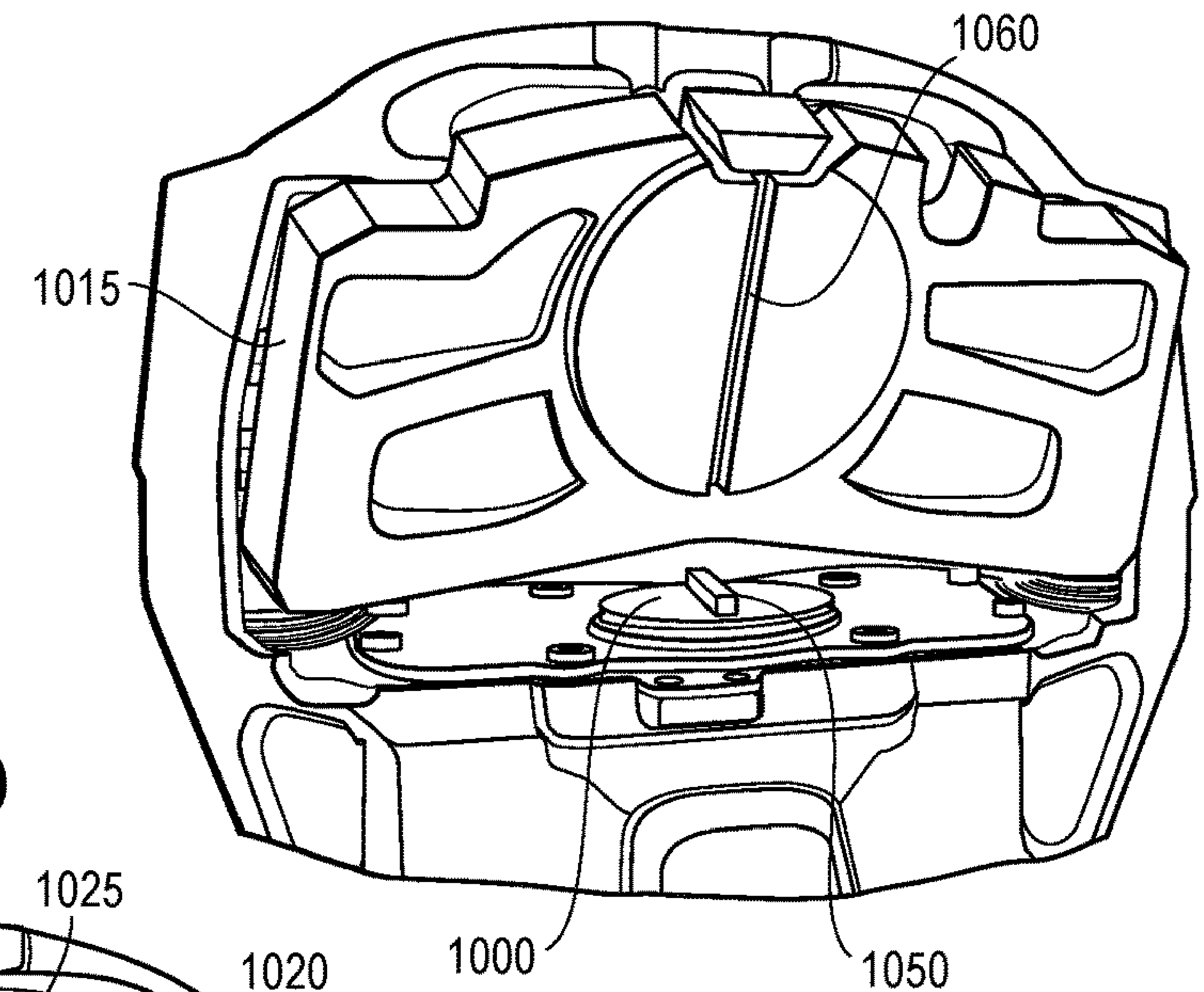

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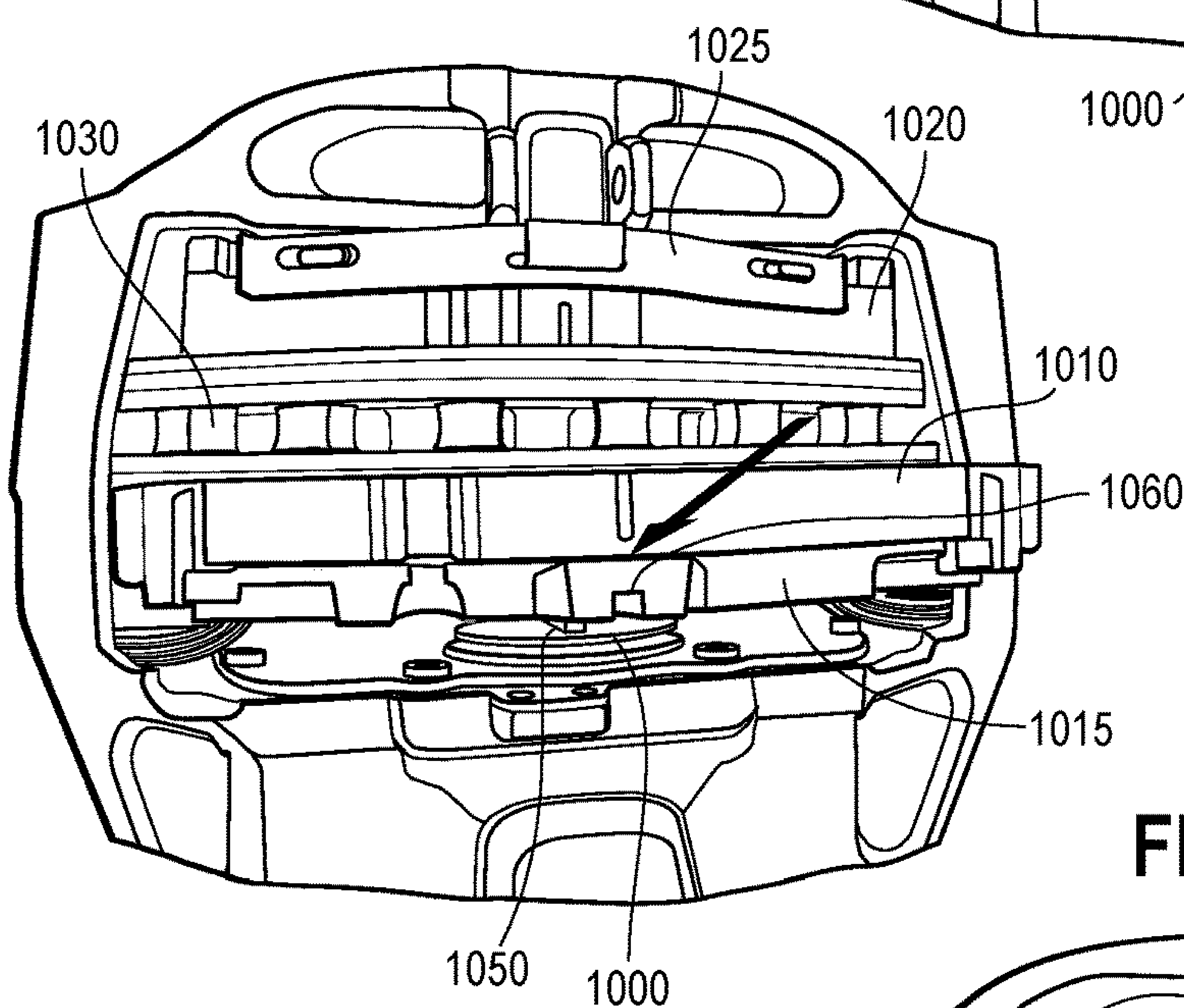

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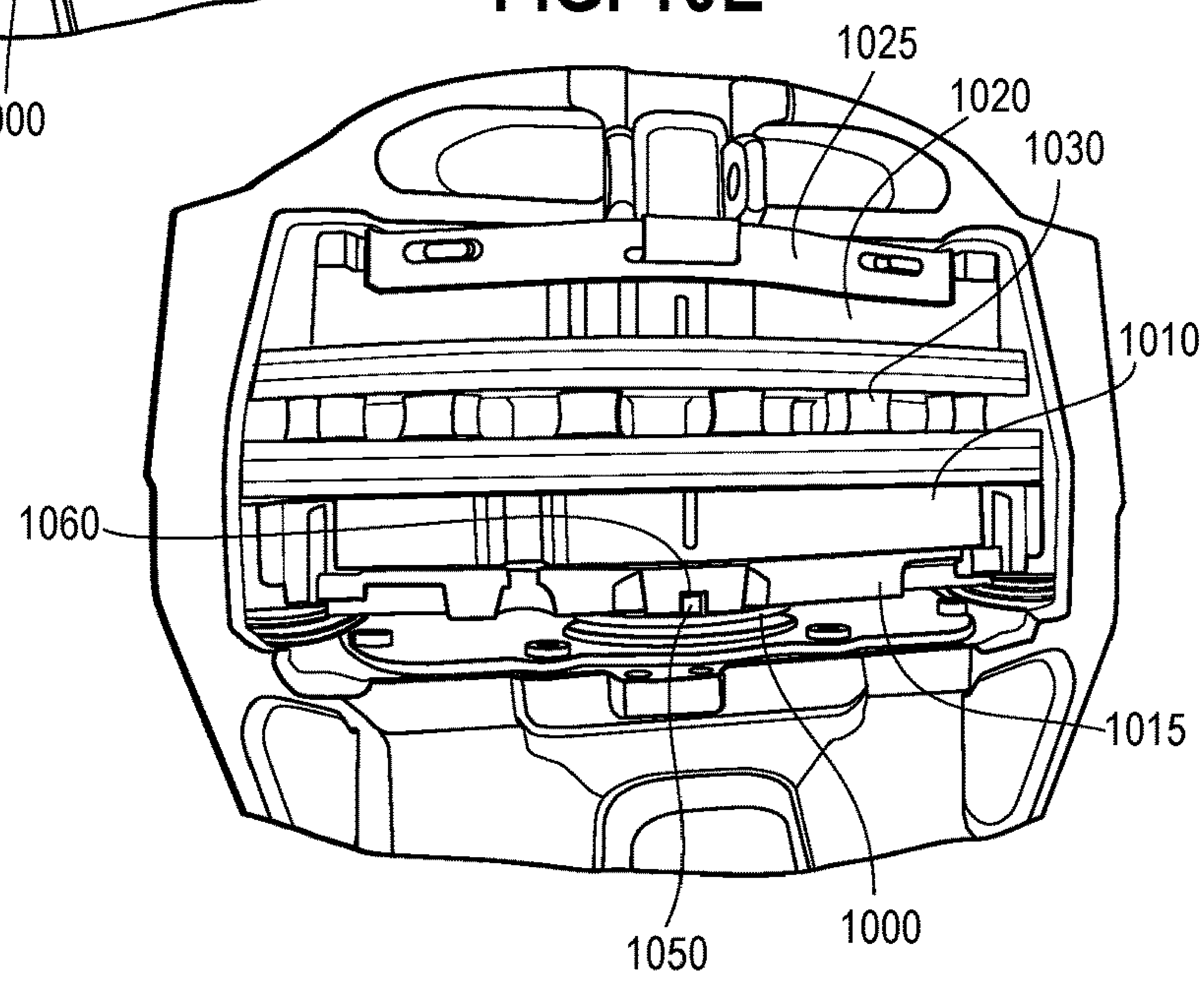

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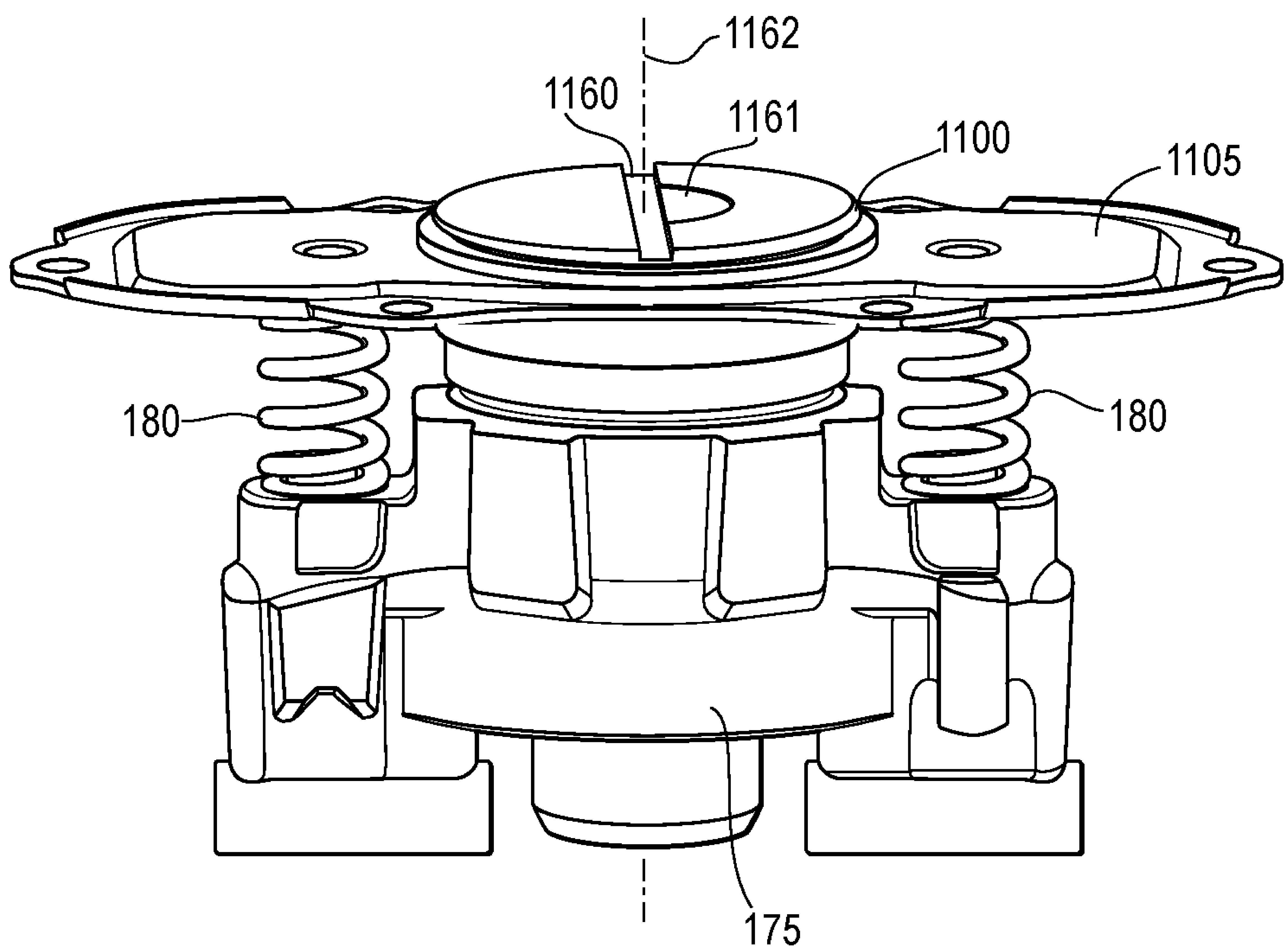

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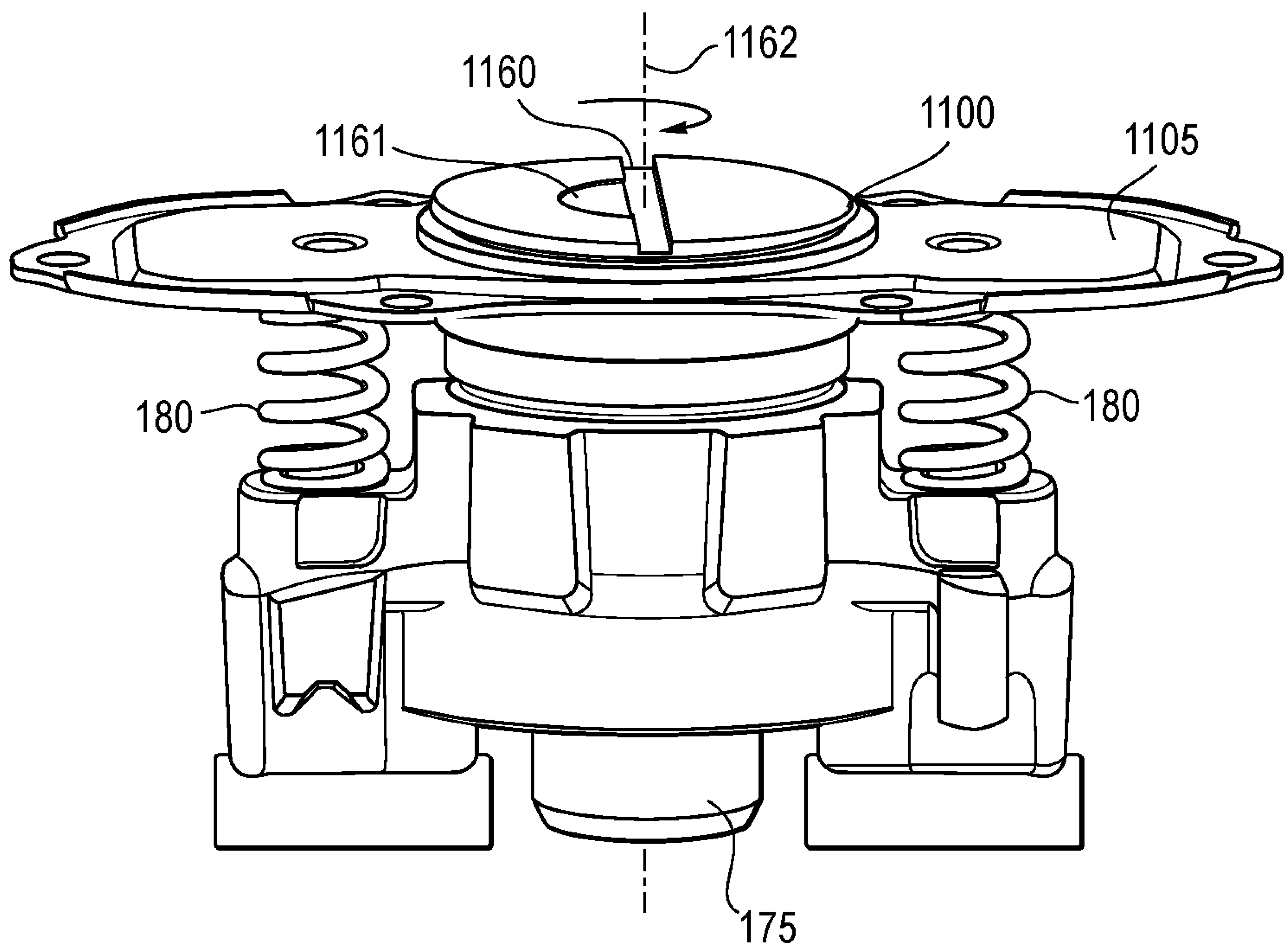

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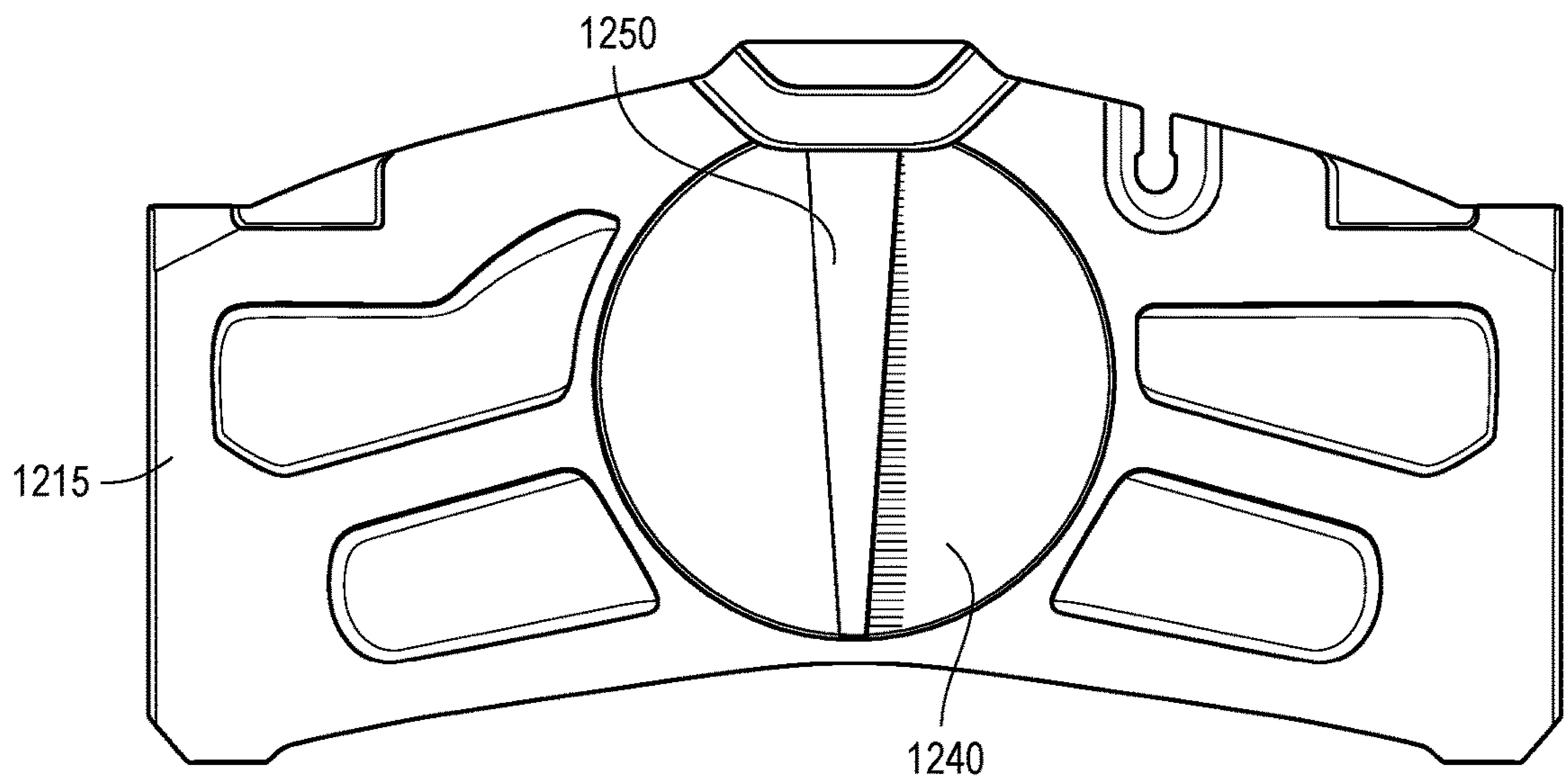

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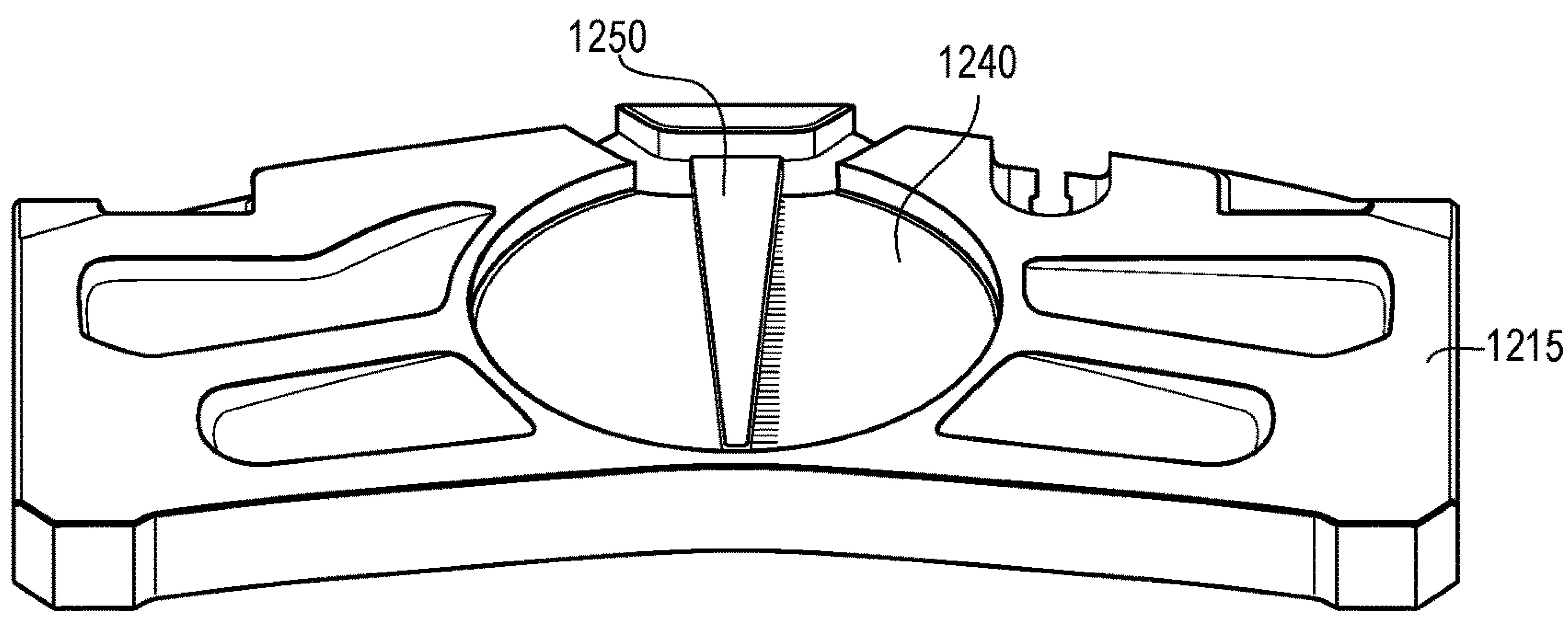

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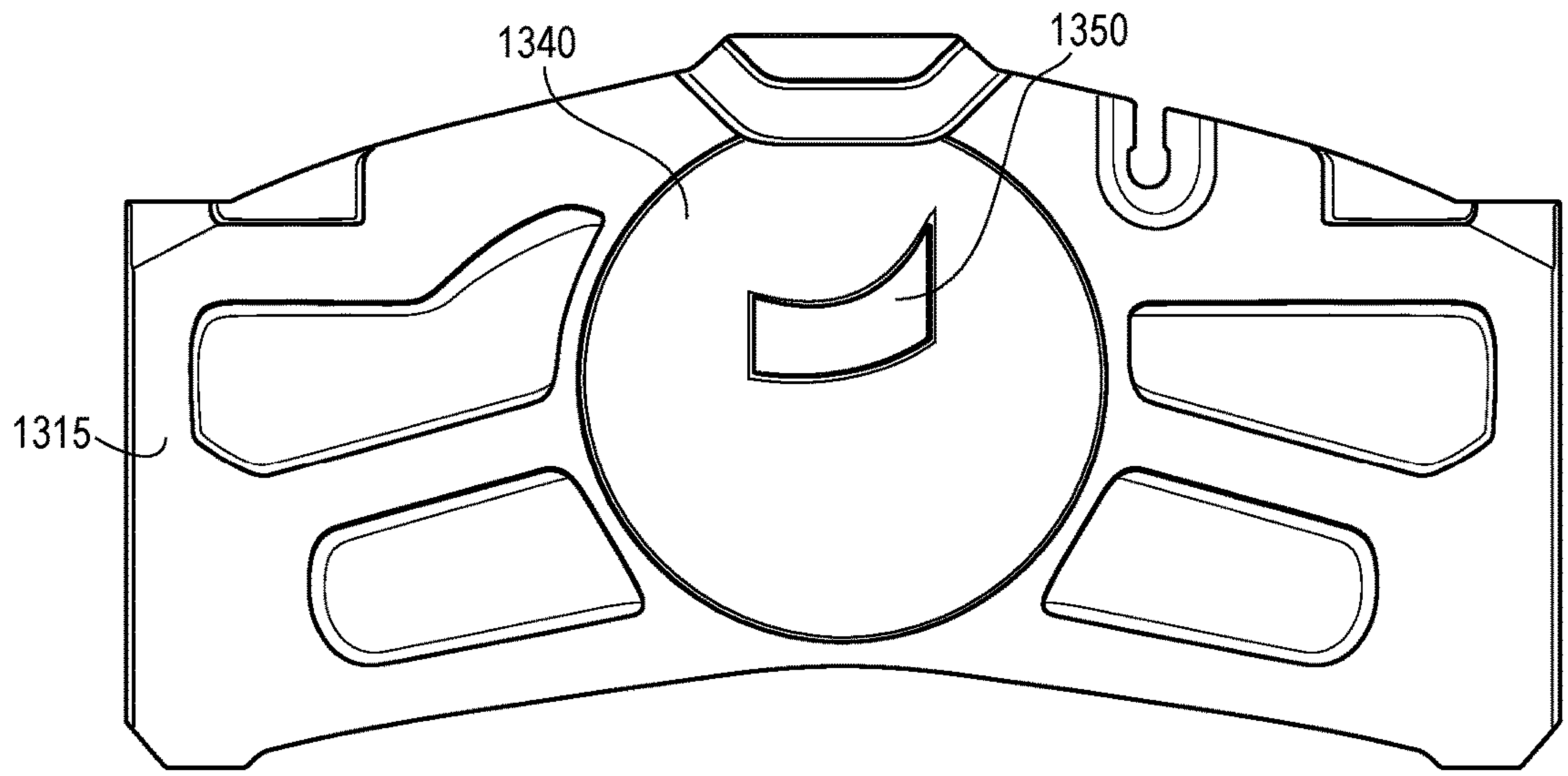

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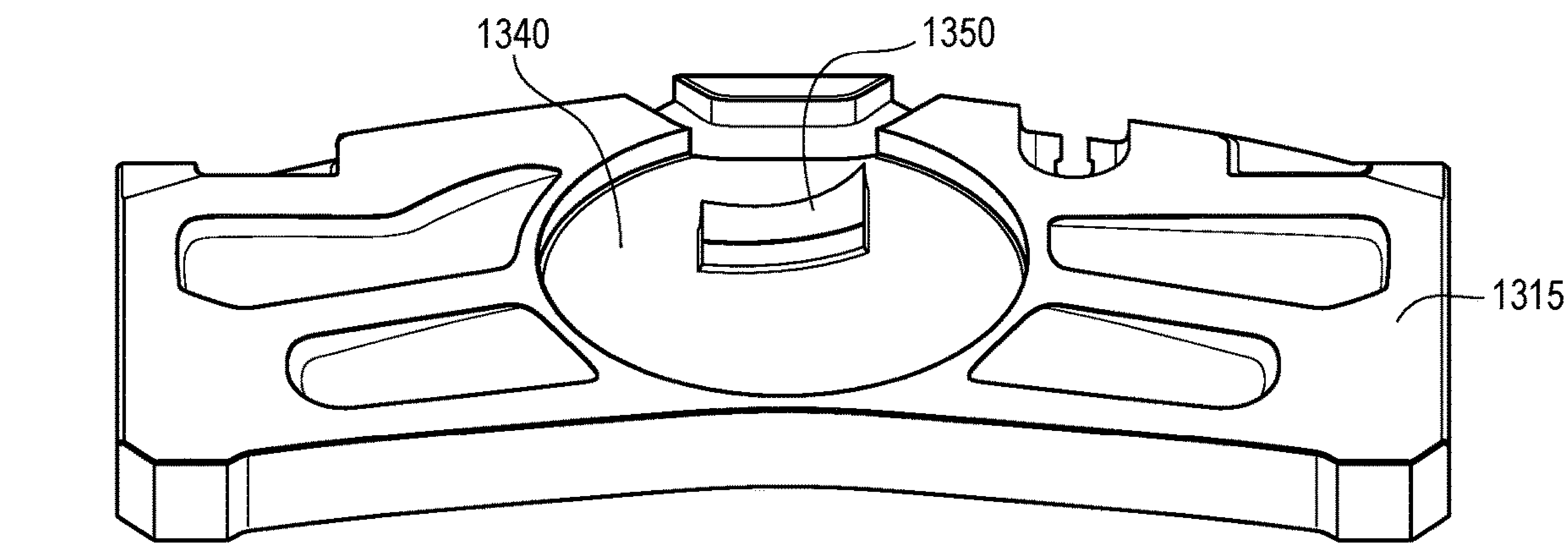

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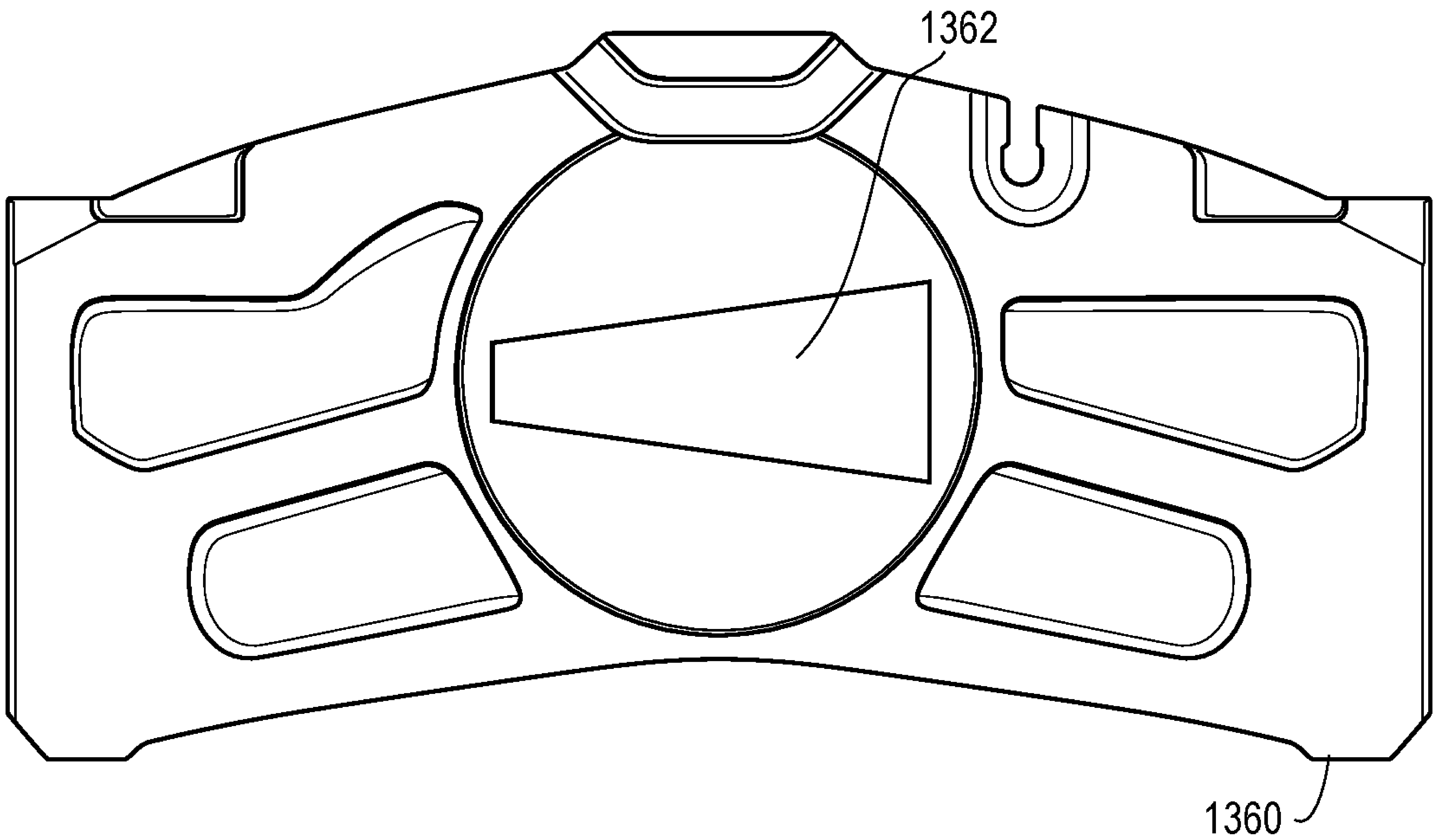

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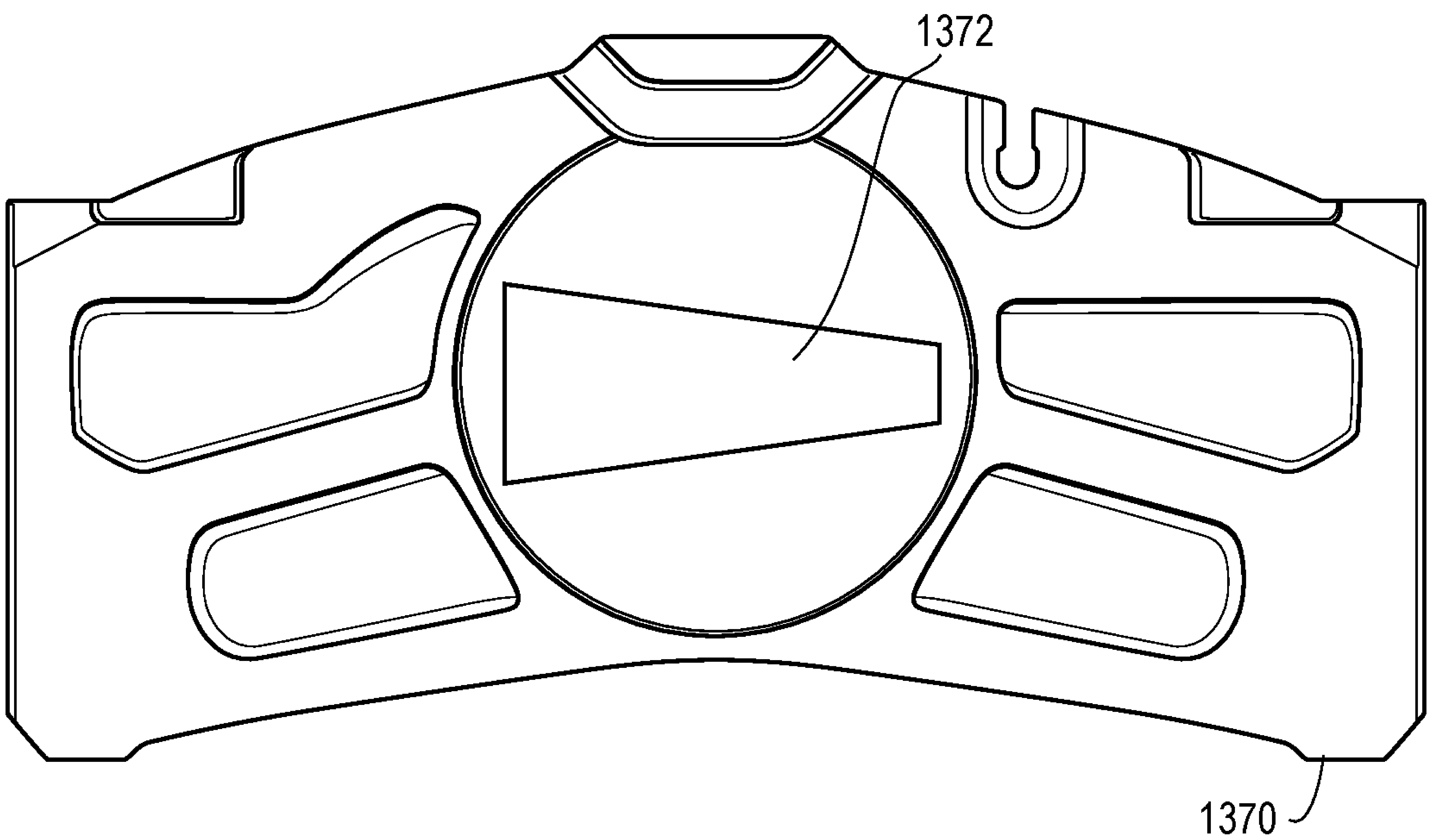

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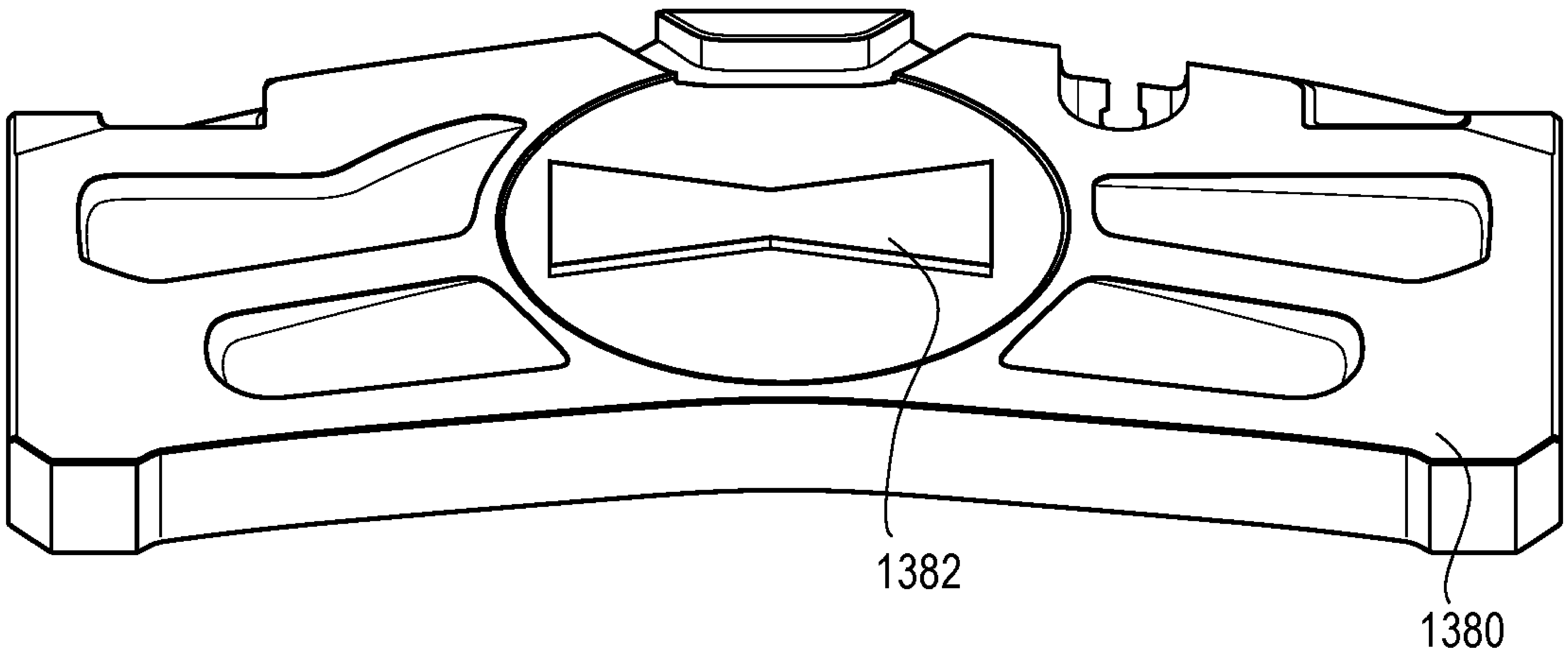

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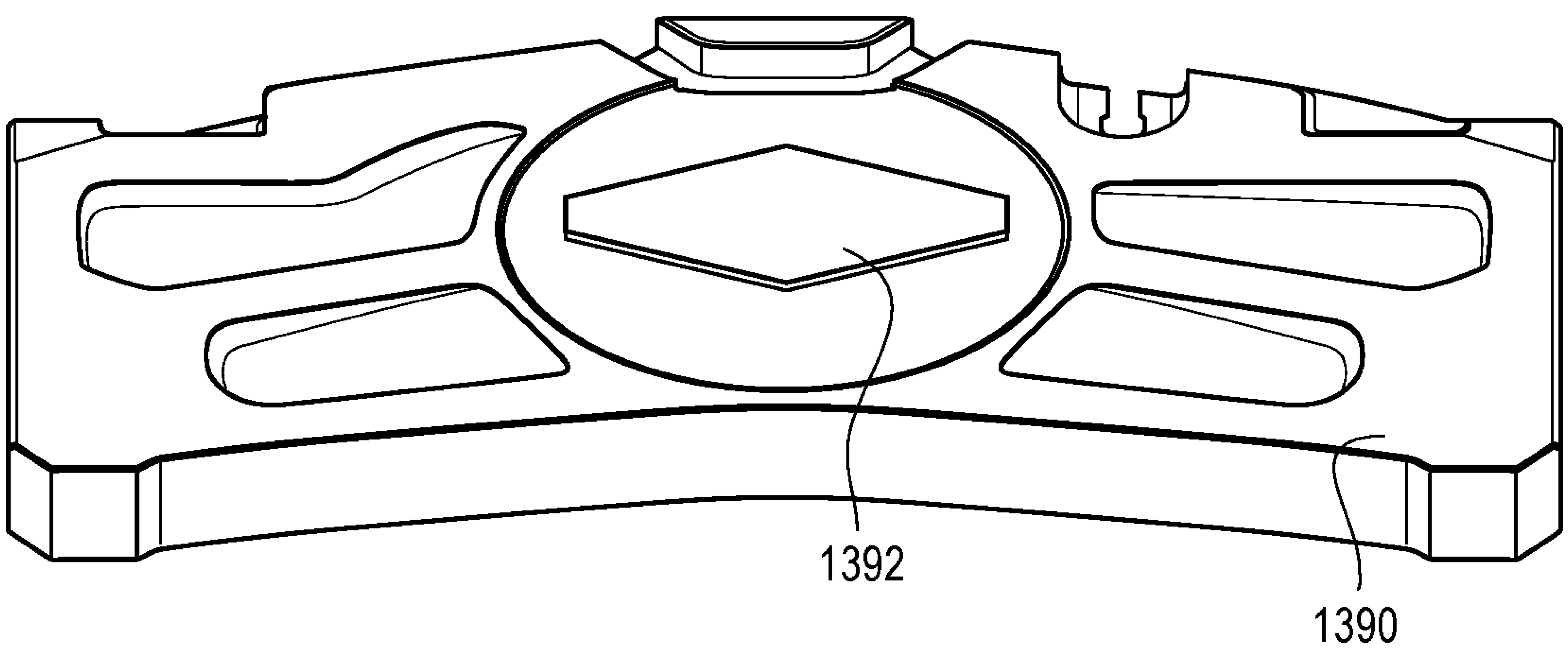

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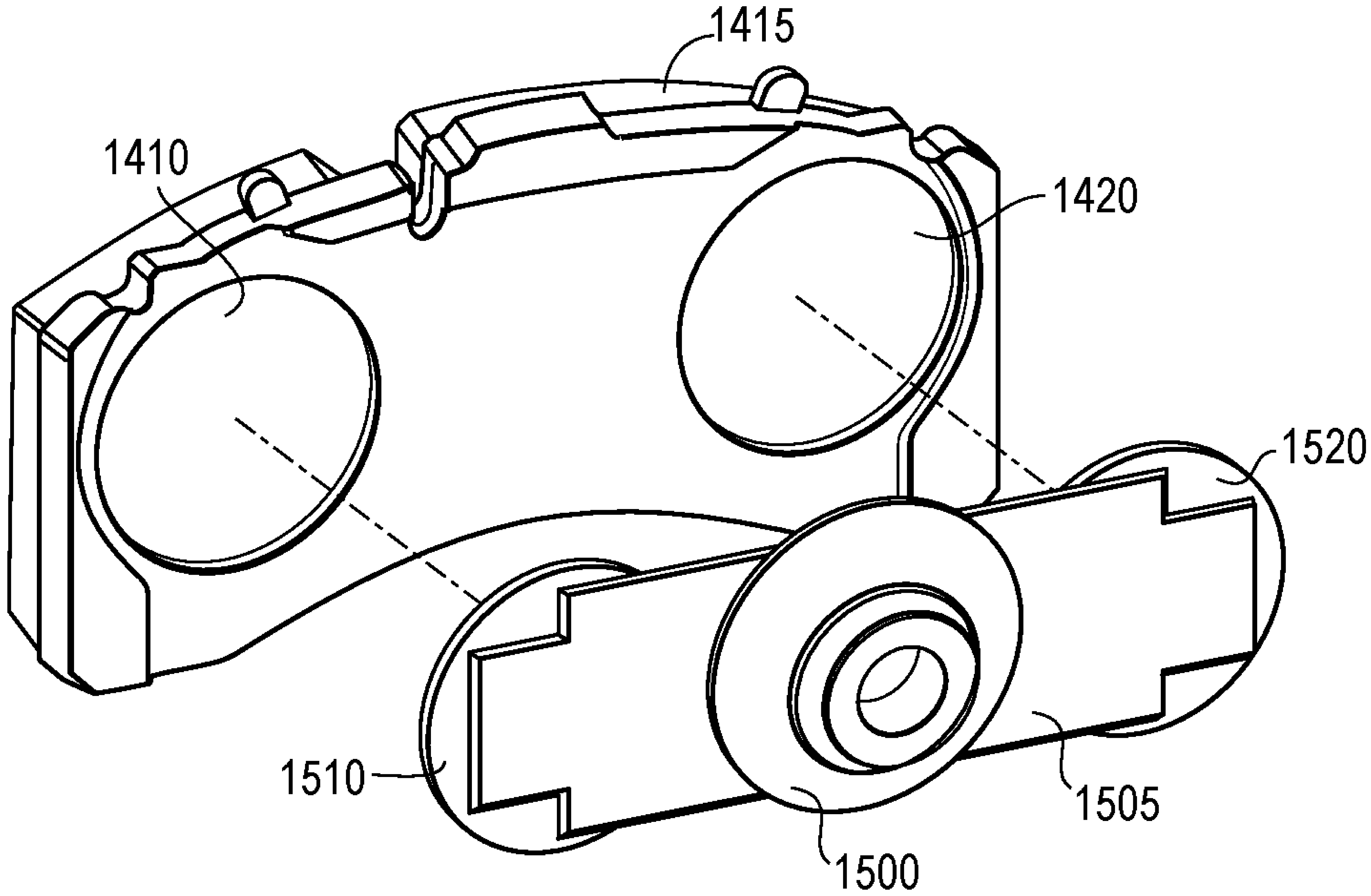

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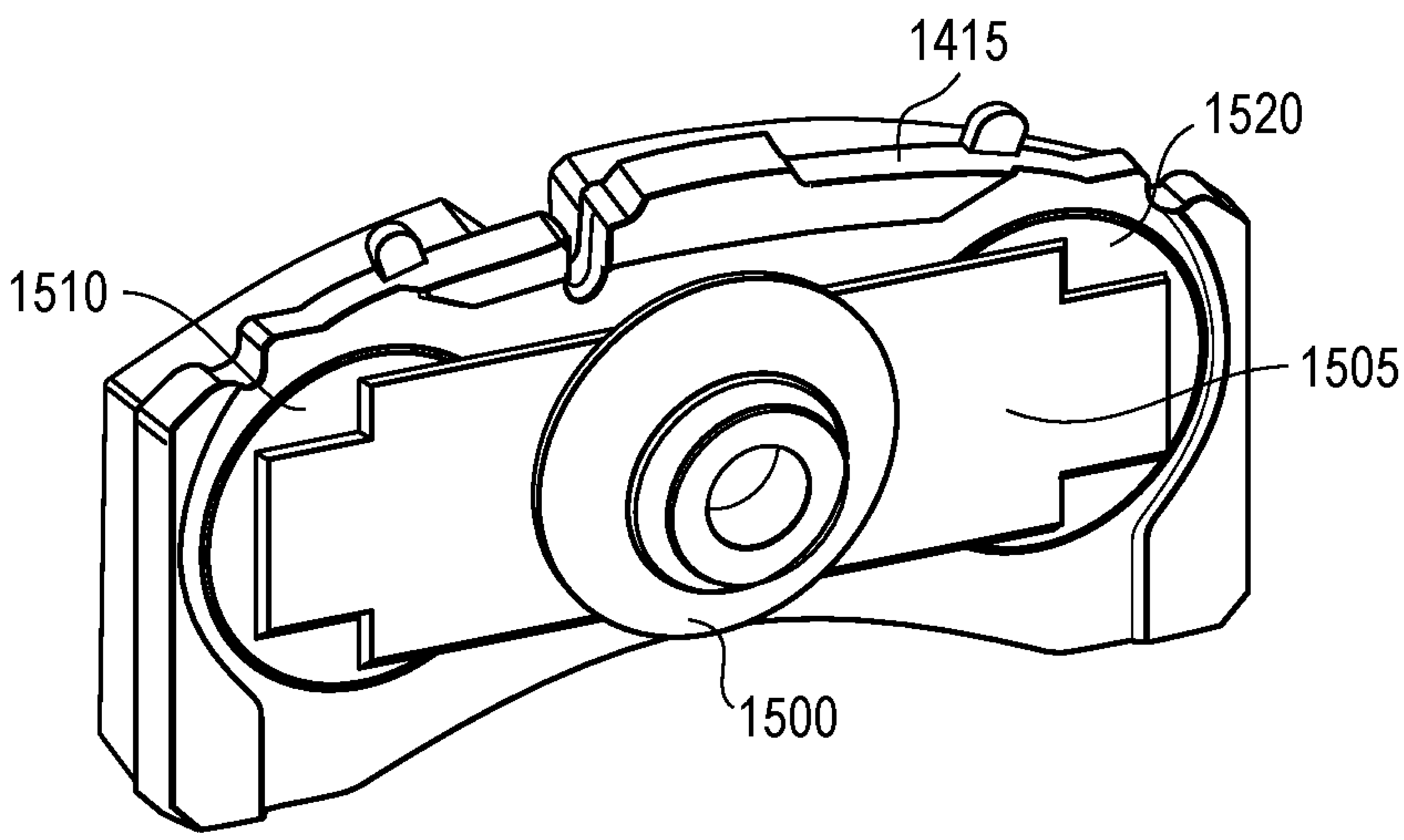
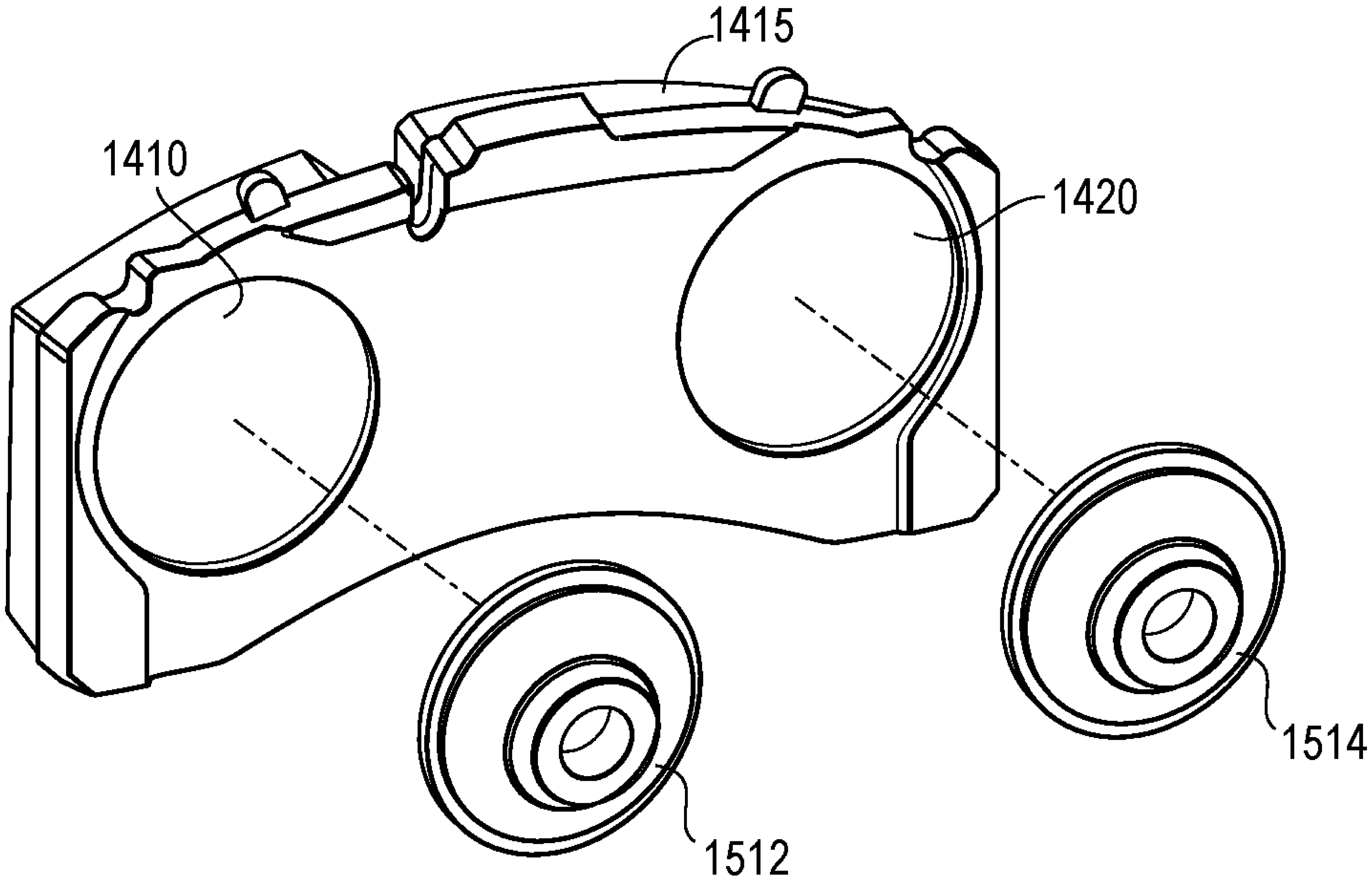


FIG. 15C



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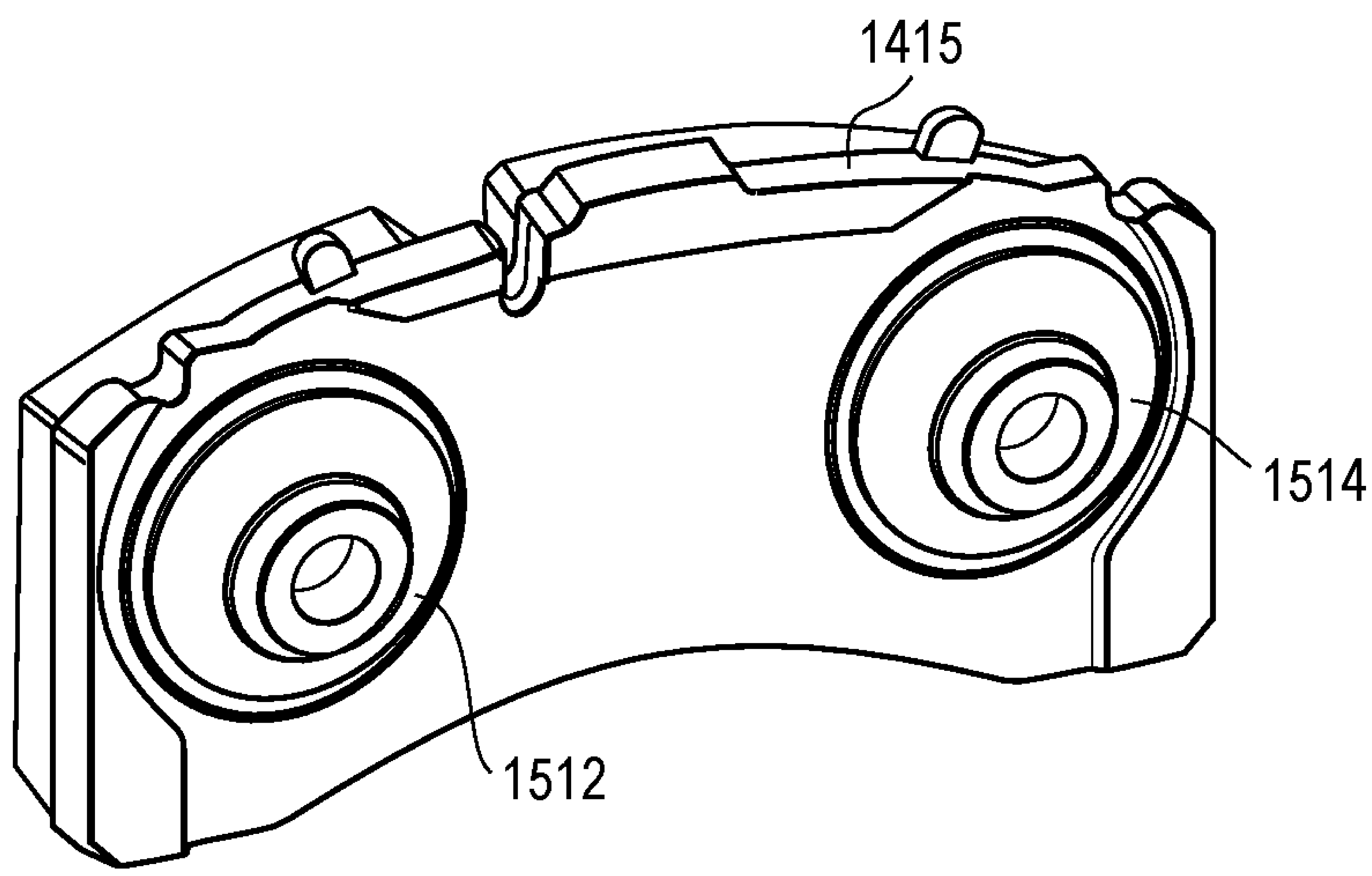


FIG. 16A

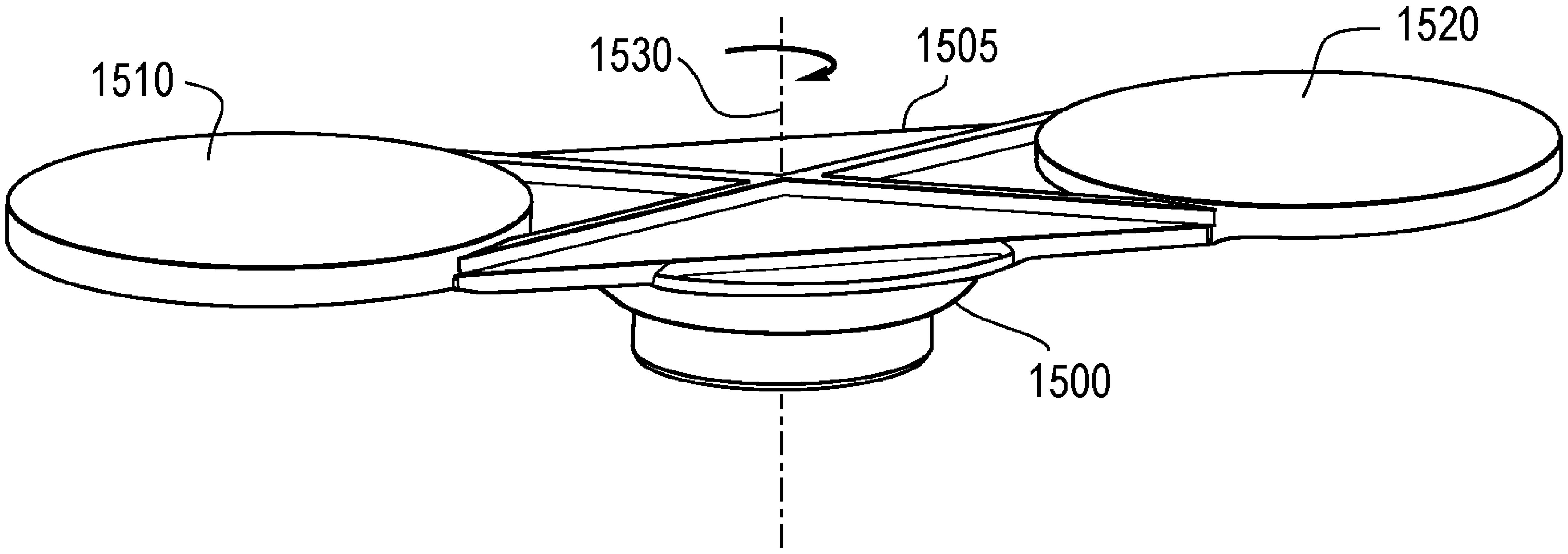
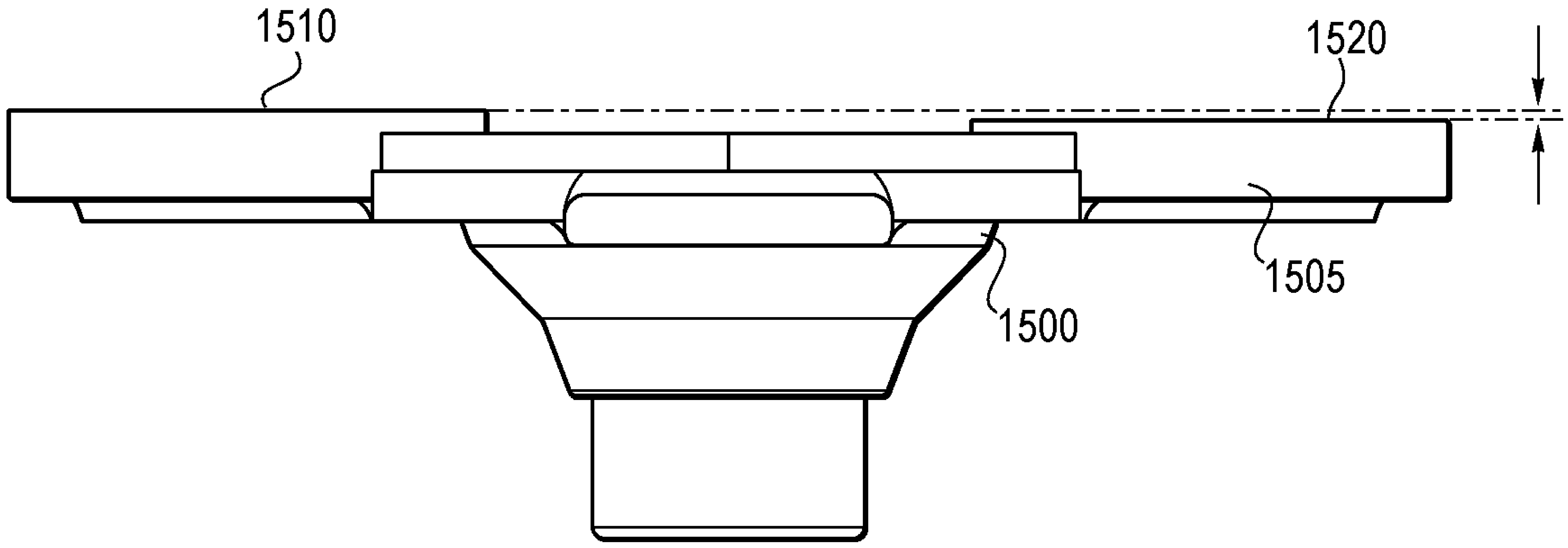


FIG. 16B



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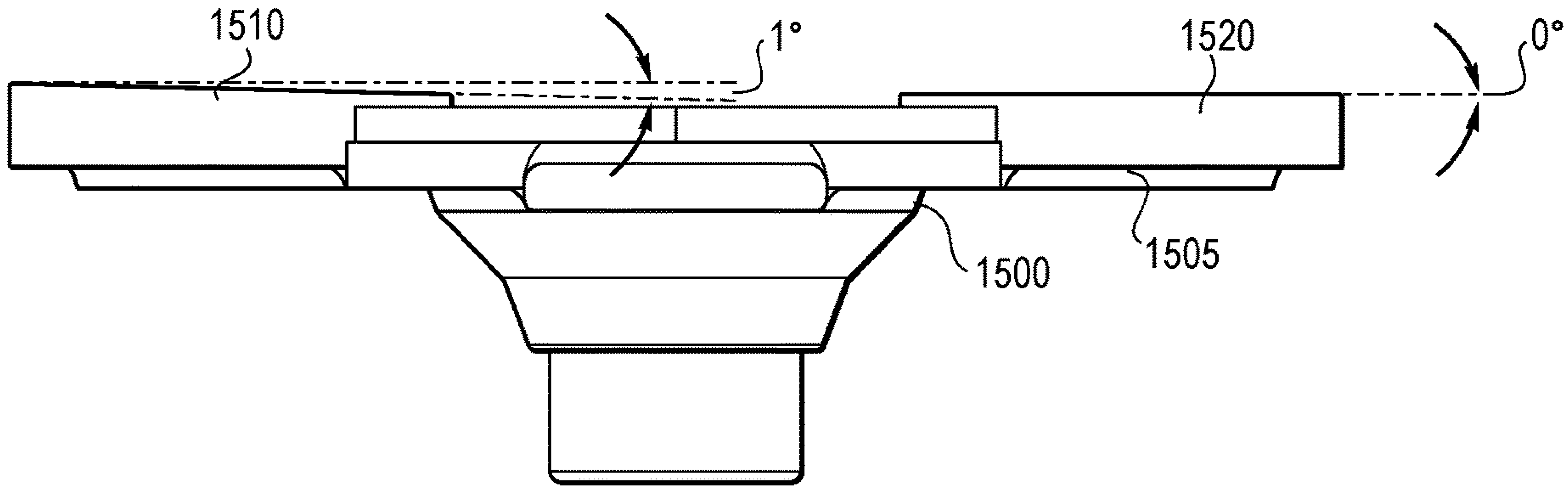

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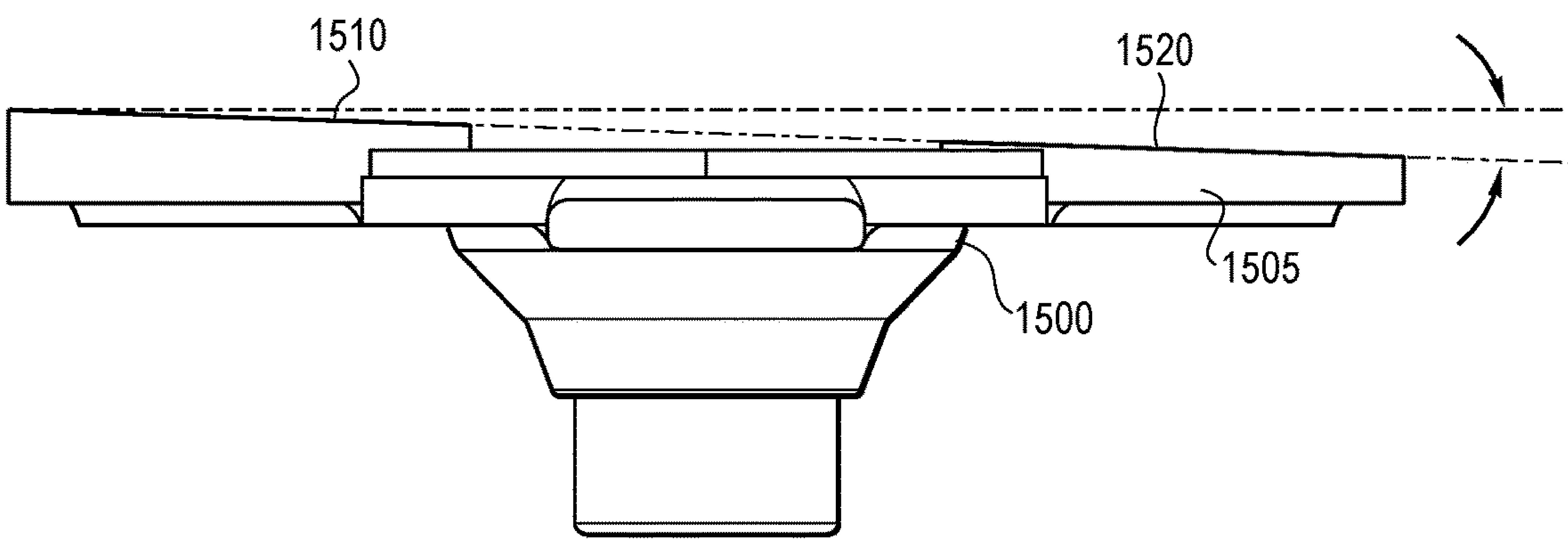

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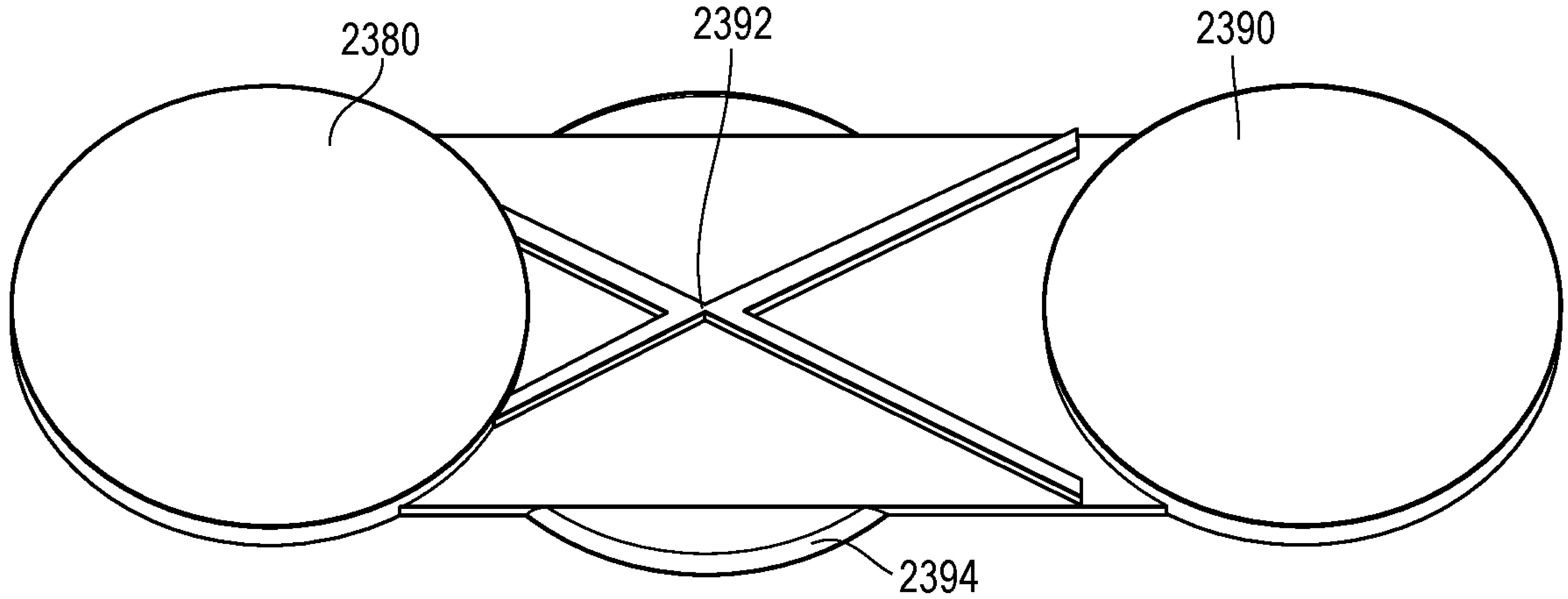

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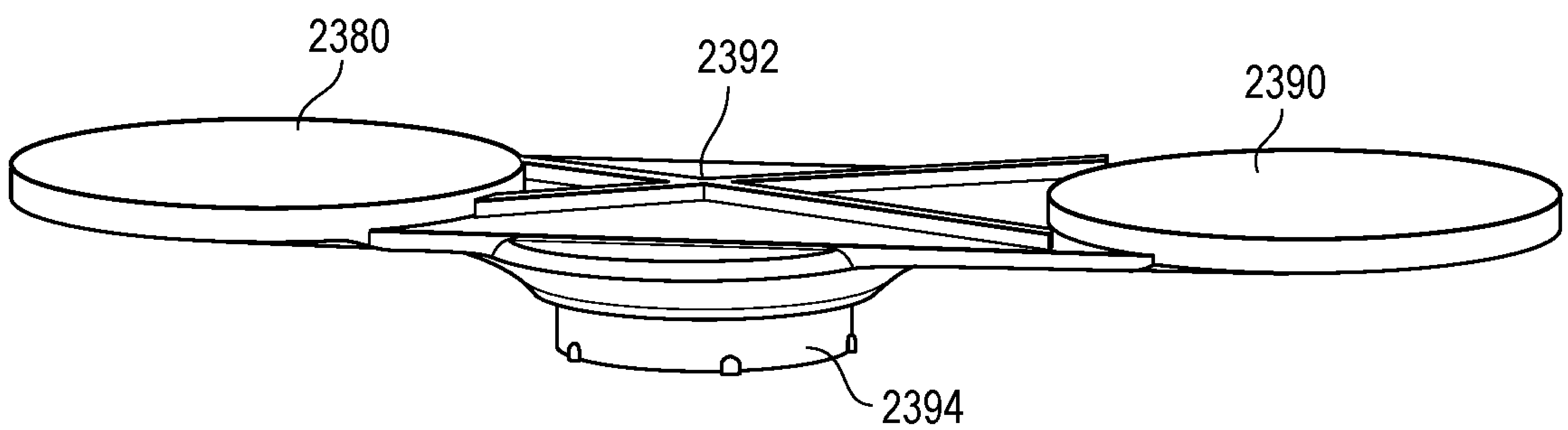


FIG. 17A

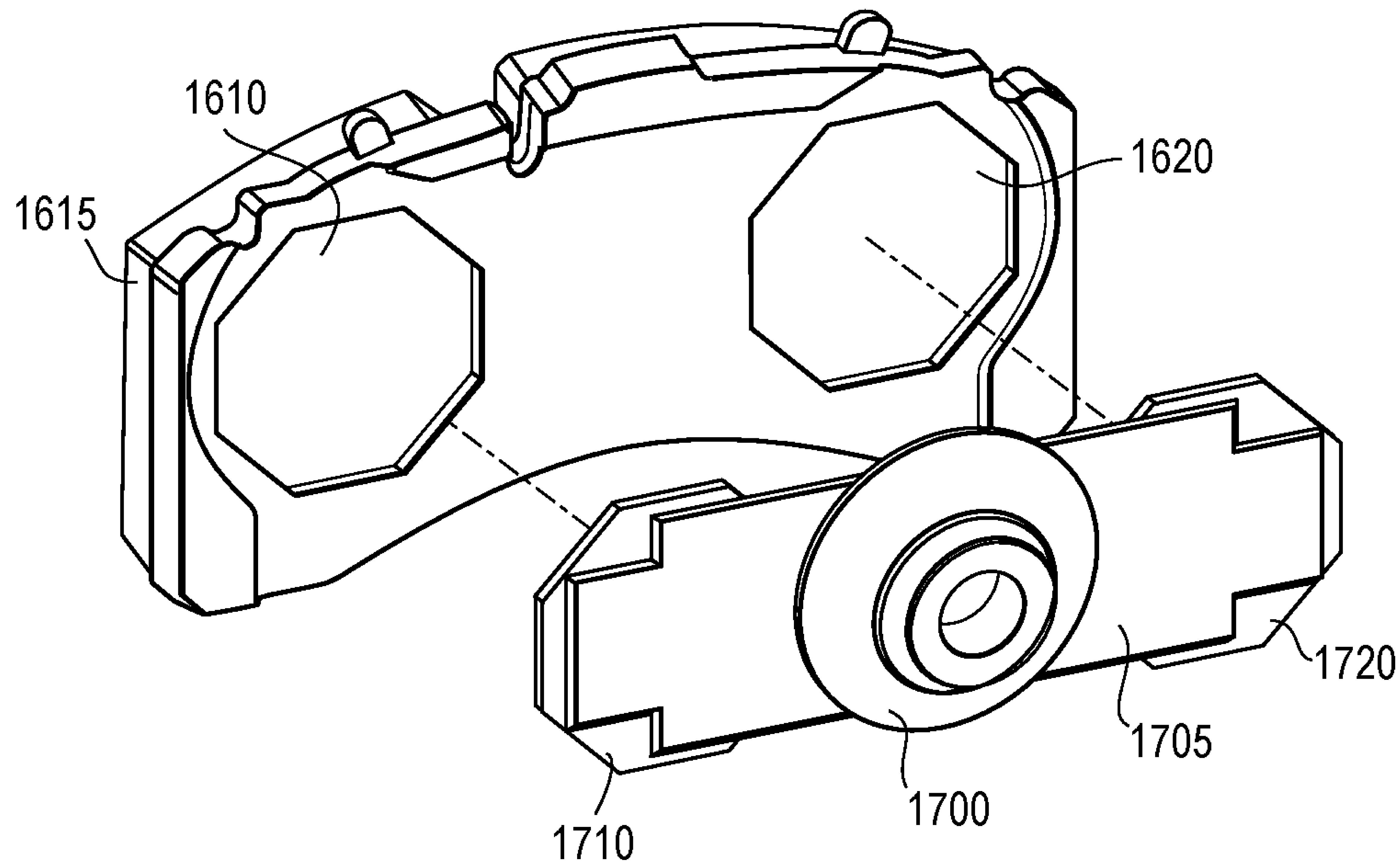


FIG. 17B

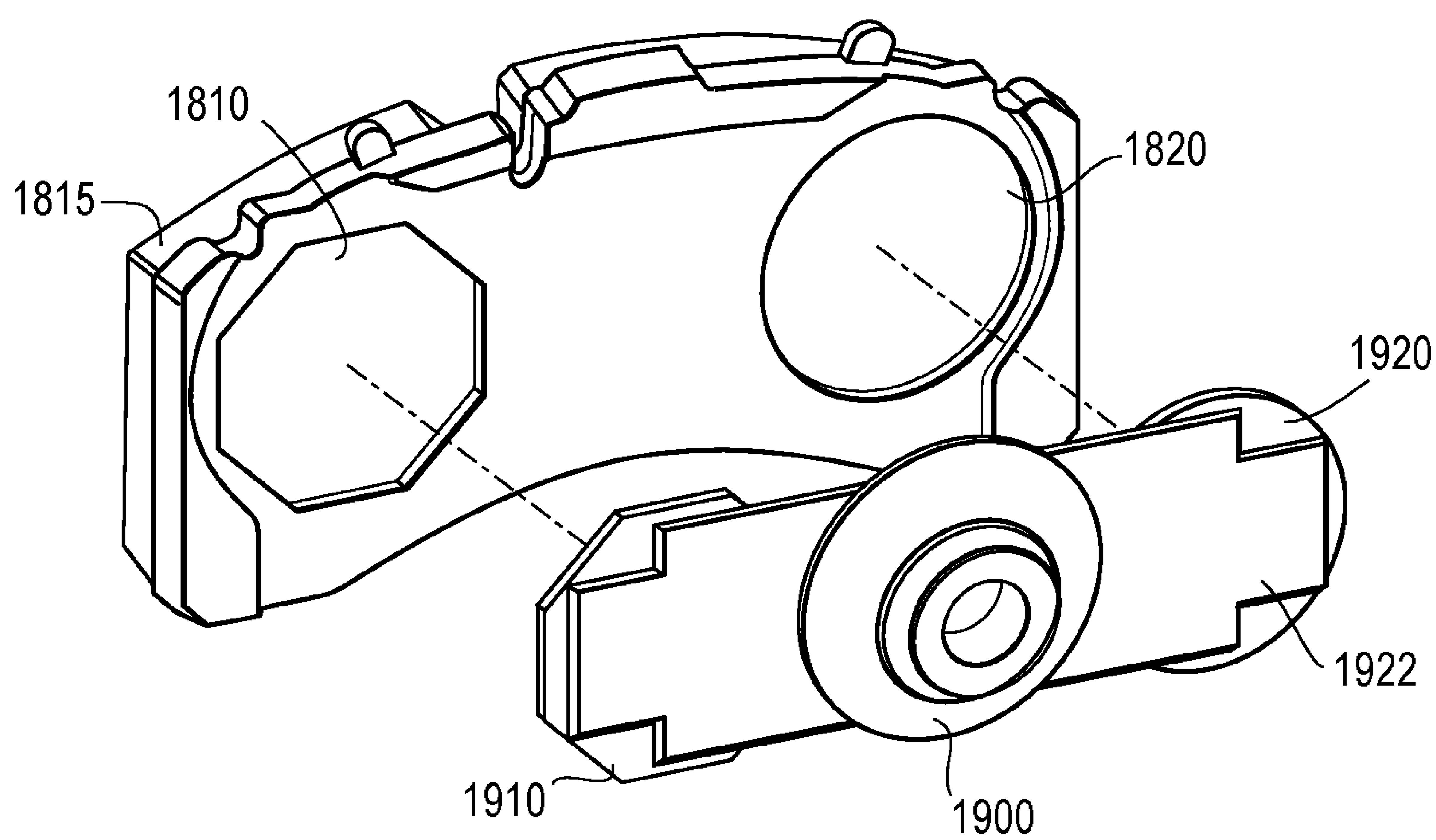


FIG. 18A

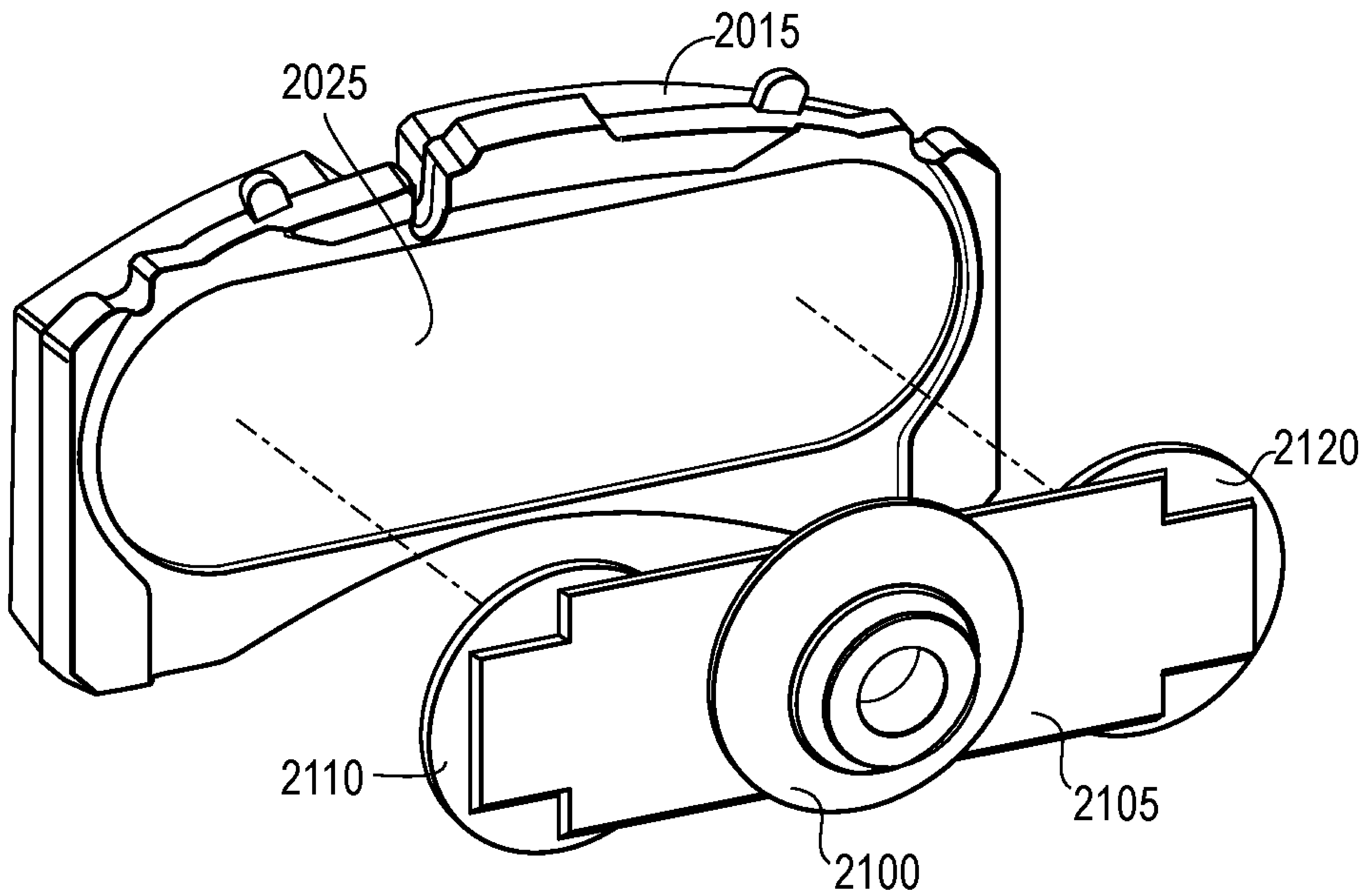


FIG. 18B

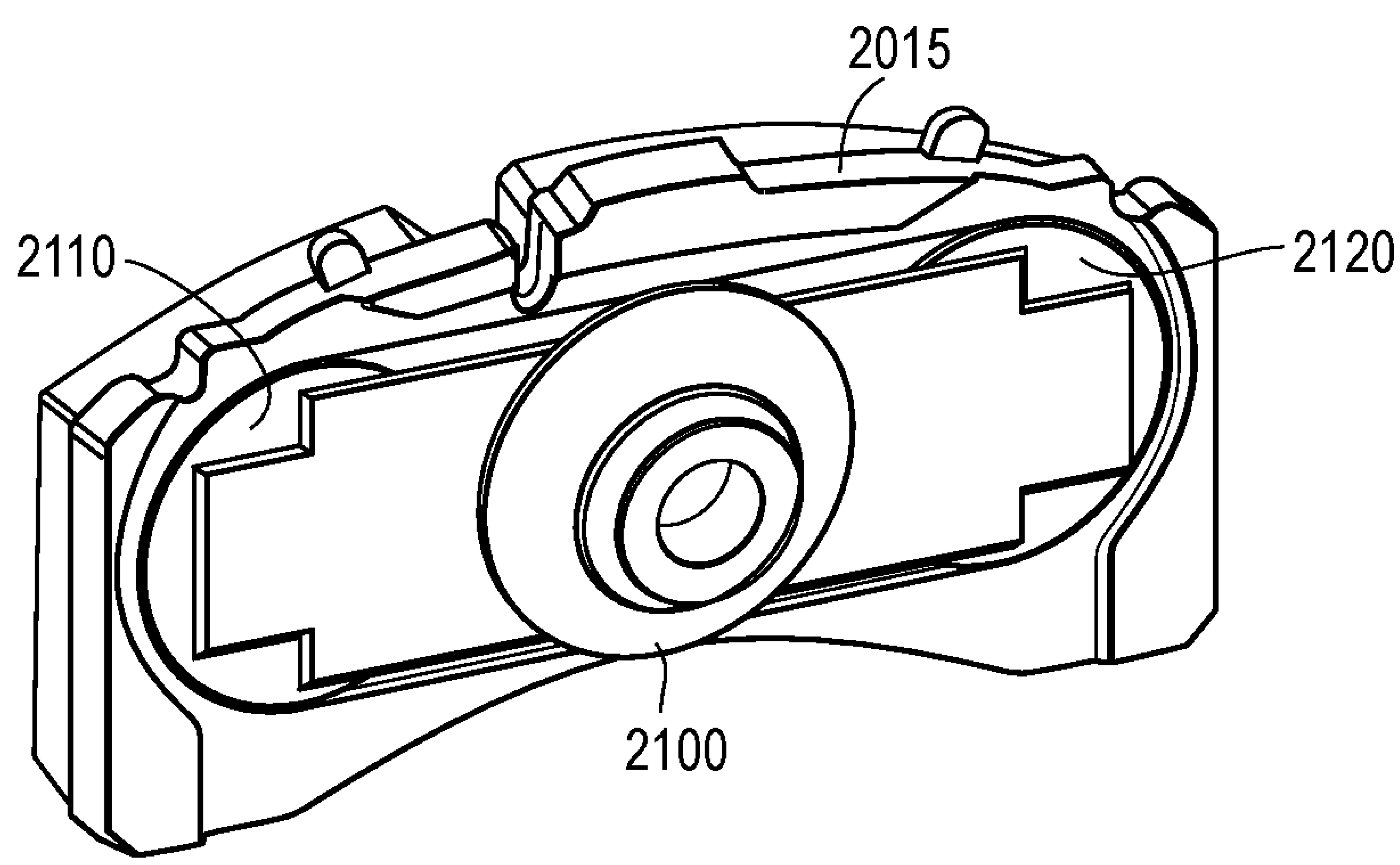


FIG. 19A

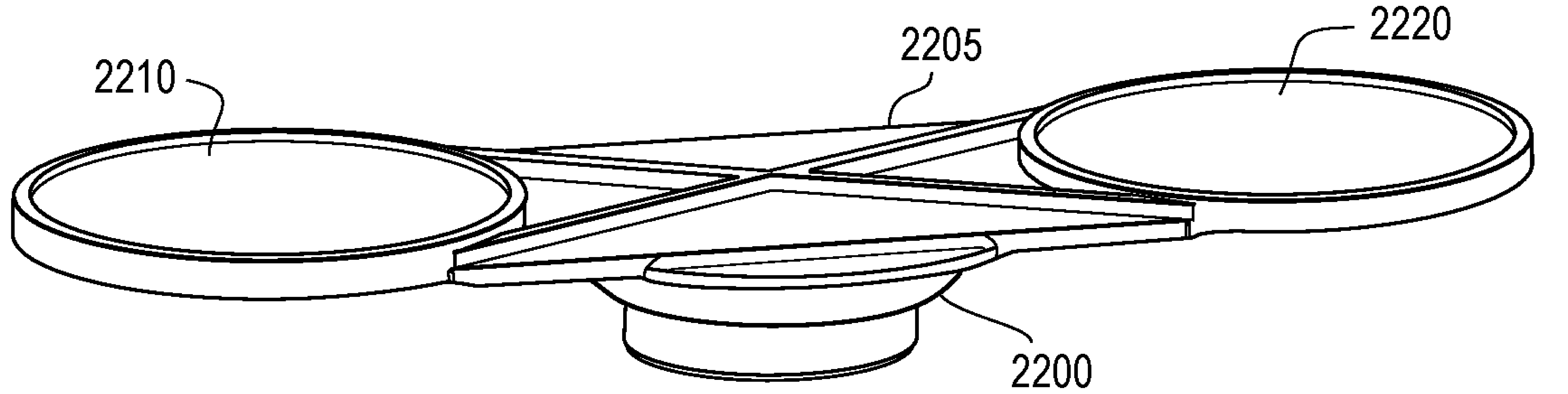
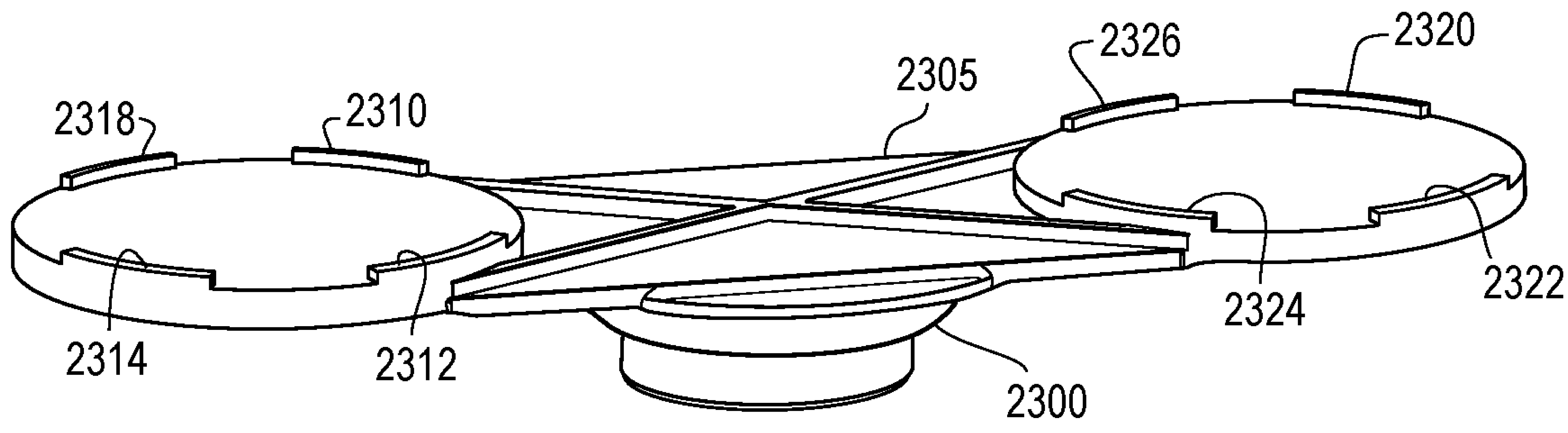


FIG. 19B



SINGLE AIR DISC BRAKE TAPPET WITH FEATURES THAT MIMIC MULTIPLE TAPPETS

BACKGROUND

In some air disc brake systems, when the brakes are applied, air pushes two spaced-apart tappets against a backing plate of an inner brake pad, which moves the inner brake pad in contact with a rotor coupled with a wheel. In other air disc brake systems, a single tappet is used that is positioned to contact the middle of the backing plate. During braking, the rotor rotates, and the brake pad is applied against it to create a braking force. A resulting unequal force distribution caused by the moment created between the brake pad drag force and abutment force can lead to uneven distribution of the braking force and, hence, uneven wear of the inner brake pad. Various solutions have been proposed to address this problem.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is an illustration of an air disc brake system an embodiment.

FIG. **1**B is an illustration of longitudinal tapered wear forces on an air disc brake system of an embodiment.

FIG. **2**A is a side view of a tappet of an embodiment.

FIG. **2**B is a top view of a tappet of an embodiment.

FIG. **2**C is a bottom view of a tappet of an embodiment.

FIG. **3**A is an illustration of a brake pad backing plate of an embodiment.

FIG. **3**B is an illustration of a tappet pushing against a brake pad backing plate of an embodiment.

FIG. **4**A is an illustration of a tappet of an embodiment with a zero-degree tilt.

FIG. **4**B is an illustration of a tappet of an embodiment with a one-degree tilt.

FIG. **5**A is an illustration of a tappet and a brake pad backing plate of an embodiment prior to contact.

FIG. **513** is an illustration of a tappet and a brake pad backing plate of an embodiment at initial contact.

FIG. **5**C is an illustration of a tappet and a brake pad backing plate of an embodiment in full contact.

FIG. **6**A is a side view of a tappet of an embodiment.

FIG. **6**B is a side view of the tappet in FIG. **6**A rotated 180 degrees.

FIG. **7**A is an illustration of a brake pad backing plate of an embodiment with a raised surface.

FIG. **7**B is an illustration of a tappet of an embodiment having a recess that mates with the raised surface in the brake pad backing plate of FIG. **7**A.

FIG. **8**A is an illustration of a brake pad backing plate of an embodiment with a raised surface.

FIG. **8**B is a side view of a tappet of an embodiment having with a recess that mates with the raised surface in the brake pad backing plate in FIG. **8**A,

FIG. **8**C is a perspective view of the tappet in FIG. **8**B.

FIG. **81**) is a side view of a tappet of an embodiment having with a recess and a non-tapered top surface.

FIG. **8**E is a side view of a tappet of an embodiment having with a recess and portions with non-tapered but non-uniform heights.

FIG. **9**A is an illustration of a brake pad backing plate of an embodiment with a raised surface offset from a center of the brake pad backing plate.

FIG. **9**B is a side view of a tappet of an embodiment having with a recess and a tapered top surface, where the recess is offset from the center of the tappet.

FIG. **10**A is an illustration of a brake pad backing plate of an embodiment with a recess,

FIG. **10**B is a side view of a tappet of an embodiment having a raised surface that mates with the recess in the brake pad backing plate in FIG. **10**A.

FIG. **10**C is an illustration of a brake pad backing plate of an embodiment prior to the brake pad backing plate being installed in a braking system.

FIG. **101**) is an illustration of a brake pad backing plate of an embodiment being installed into a braking system.

FIG. **10**E, is an illustration of a brake pad backing plate of an embodiment installed in a braking system.

FIG. **11**A is a perspective view of a tappet of an embodiment.

FIG. **11**B is a perspective side view of the tappet in FIG. **11**A rotated ISO degrees.

FIG. **12**A is a top view of a brake pad backing plate of an embodiment with a triangular raised surface.

FIG. **12**B is a perspective bottom view of the brake pad backing plate of FIG. **12**A.

FIG. **13**A is a top view of a brake pad backing plate of an embodiment with a curved trapezoidal-type raised surface.

FIG. **13**B is a perspective bottom view of the brake pad backing plate of FIG. **13**A,

FIGS. **14**A-**14**D are illustrations of a brake pad backing plate of an embodiment with horizontal features,

FIG. **15**A is an illustration of a brake pad backing plate and a single tappet of an embodiment that has features that mimic multiple tappets.

FIG. **15**B is an illustration of a tappet pushing against a brake pad backing plate of an embodiment,

FIG. **15**C is an illustration of a brake pad backing plate and a double tappet of an embodiment.

FIG. **15**D is an illustration of double tappets pushing against a brake pad backing plate of an embodiment.

FIG. **16**A is a perspective view of a tappet of an embodiment with two raised features that mimic two tappets.

FIG. **16**B is a side view of a tappet of an embodiment where the two raised features that mimic two tappets have non-tapered but non-uniform heights.

FIG. **16**C is a side view of a tappet of an embodiment where one of the two raised features that mimic two tappets is tapered.

FIG. **16**D is a side view of a tappet of an embodiment where both of the two raised features that mimic two tappets are tapered.

FIGS. **16**E and **16**F are illustrations of a tappet of an embodiment that has offset features that mimic multiple tappets.

FIG. **17**A is an illustration of a brake pad backing plate and a tappet of an embodiment that has features that mimic multiple tappets.

FIG. **1713** is an illustration of a brake pad backing plate and a tappet of an embodiment that has features that mimic multiple tappets.

FIG. **18**A is an illustration of a brake pad backing plate and a tappet of an embodiment that has features that mimic multiple tappets.

FIG. **18**B is an illustration of a tappet pushing against a brake pad backing plate of an embodiment.

FIG. **19**A is a perspective view of a tappet of an embodiment with two raised features that mimic two tappets.

FIG. **19**B is a perspective view of a tappet of an embodiment with two raised features that mimic two tappets.

SUMMARY

The following embodiments relate to a single air disc brake tappet with features that mimic multiple tappets. In one embodiment, an air disc brake tappet is provided comprising: a support member; and a plate coupled with support member, wherein the plate comprises a plurality of raised features that mimic a plurality of air disc brake tappets.

In another embodiment, an air disc brake pad is provided comprising: a friction material; and a backing plate coupled with the friction material, wherein the backing plate comprises at least one recess shaped and positioned to receive a plurality of raised features of an air disc brake tappet, wherein the plurality of raised features mimics a plurality of air disc brake tappets.

In yet another embodiment, an air disc brake system is provided comprising an air disc brake pad and an air disc brake tappet. The air disc brake pad comprises: a friction material; and a backing plate coupled with the friction material, wherein the backing plate comprises at least one recess. The air disc brake tappet comprises: a support member; and a plate coupled with support member, wherein the plate comprises a plurality of raised features that mimic a plurality of air disc brake tappets, wherein the plurality of raised features are shaped and positioned to mate with the at least one recess of the backing plate.

Other embodiments are possible, and each of the embodiments can be used alone or together in combination.

DETAILED DESCRIPTION

General Overview of an Air Disc Brake System

Turning now to the drawings, FIG. **1**A is an illustration of an air disc brake system **100** of an embodiment. As shown in FIG. **1**A, this system **100** comprises an inner brake pad **110** and an outer brake pad **120** in proximity to a brake rotor **130** coupled with a wheel of a vehicle. Each brake pad **110**, **120** comprises a friction material (e.g., a mixture of different particles of material) configured to slow the rotation of the rotor **130** when the brake pads **110**, **120** press against the rotor. Each brake pad **110**, **120** is bonded to a respective backing plate **115**, **125**, which can be made from cast iron or steel, for example. A floating caliper **135** couples the two brake pads **110**, **120**.

In operation, when the vehicle brakes are applied (e.g., when a driver presses a brake pedal or an automated driving system generates an electronic signal to apply the brakes), air enters a service brake chamber **140** through a supply port **145**, applying pressure within a diaphragm **150**. The pressure expands the diaphragm **150**, thereby applying force to and moving a pressure plate **155** and a pushrod **160** forward. The pushrod **160** acts against a cup in an internal lever **165**, which pivots on an eccentric bearing **170** to move a bridge **175**. Moving against a return spring **180**, the bridge **175** transfers the motion to a support memory (e.g., a threaded tube, which is not shown) and a tappet **200**, which contacts the inner brake pad's backing plate **115** to move the inner brake pad **110** into contact with the rotor **130**. Further movement of the bridge **175** forces the floating caliper **135** (sliding on two stationary guide pins (not shown)) away from the rotor **130**. That, in turn, pulls the outer brake pad **120** into the rotor **130**. The clamping action of the brake pads **110**, **120** on the rotor **130** applies braking force to the wheel. When the vehicle brakes are released, the air pressure in the service brake chamber **140** is exhausted, and the return spring **180** in the bridge **175** and a return spring **185** in the service brake chamber **140** return the air disc brake to a

neutral, non-braked position. It should be understood that this is merely an example and that other configurations can be used.

As noted above, when the brakes are applied, air forces the tappet **200** (coupled with a support, such as a threaded tube) into contact with the inner brake pad's backing plate **115**. The combination of the tappet **200** and threaded tube may sometime be referred to herein a plunger or piston, and the tappet **200** may sometimes be referred to herein as a pressure plate. In a two-tappet braking system, a pair of spaced-apart tappets (and threaded tubes) are used to distribute the applied force over a large area of the backing plate **115**. This results in a relatively-equalized distribution of the braking force on the backing plate **115** and, hence, the rotor **130**, which results in relatively-even wear of the inner brake pad **110**.

The brake pads **110**, **120** and rotor **130** wear away every time the brakes are applied. Over time, this increases the running clearance between the brake pads and rotor and also the tappets and the backing plate **115**. The braking system **100** can have a mechanical mechanism (not shown) for each of the two tappets to adjust the relative position of each tappet to compensate for the increased running clearance. To reduce cost and complexity (especially in vehicles that do not need the robustness of a two-tappet brake), a single tappet can be used, as using just a single tappet would eliminate half of the components in the mechanical mechanism that compensates for the increased running clearance.

Unlike a two-tappet brake which distributes braking force over left- and right-sides of the backing plate **115**, the tappet in a single-tappet brake is typically positioned in the center of the backing plate **115**. So, as compared to using a two-tappet brake, using a single-tappet brake can result in an uneven distribution of braking force and, hence, uneven wear of the inner brake pad **110**. It should be mentioned that a two-tappet brake does not eliminate tapered pad wear, but it is a common method of reducing the phenomenon as it helps to more-evenly distribute the braking force. One other note is that another common method to reduce tapered wear is to use many tappets or pistons and sometimes vary the size of them with respect to the leading and trailing ends of the pads to help mitigate tapered pad wear. More specifically, as the rotor **130** rotates, the leading edge of the inner brake pad **110** can wear more quickly due to the unequal force distribution caused by the moment created between the brake pad drag force and abutment force. These forces will be discussed in reference to FIG. **1**B.

As shown in FIG. **1**B, pressure distributed on the inboard brake pad can be referred to in two ways. The first way is static load in a static condition. In the static condition, the force distribution has a parabolic shape as seen in the diagram in the left-hand side of FIG. **1**B. The second way is dynamic load in a dynamic condition. Here, the forces output onto the pad are mostly at a right-angled triangular shape, where the larger amount of pressure is at the leading edge. In the dynamic condition, the unequal force distribution is caused by the moment created between the brake pad drag force and the carrier abutment force as shown in the right-hand side of FIG. **1**B. The maximum force at the leading edge of the brake pad is greater than the force at the trailing edge. Here, the force at the trailing edge is referred to as the minimum force. In general, the force at the leading edge might be approximately one-third greater than the average pressure. In general, the force at the trailing edge might be approximately two-thirds of the average pad pressure. This imbalance of pressure in the dynamic condition can cause each edge of the brake pad to move and/or wear differing distances upon brake application, hence, leading to tapered pad wear.

Various solutions have been proposed to address this problem, but these solutions are often complex and costly. The following embodiments provide different solutions to this problem. It should be understood that these embodiments can be used alone or in combination with one another.

Examples of Tapered Tappets for Brake Pad Wear Reduction

In one embodiment, a tapered tappet is used in a single piston system (although tapered tappets can also be used in multi-piston systems or, as will be discussed below, in a single piston system with features that mimic multiple tappets) to provide more-even distribution of brake force and brake pad wear. More specifically, in one embodiment, the tappet **200** is tilted/contoured (e.g., at a one-degree angle) with respect to the backing plate **115**, such that one end of the tappet **200** contacts the trailing edge of the backing plate **115** before the other end of the tappet **200** contacts the leading edge of the backing plate **115**. This extra force on the trailing edge of the backing plate **115** can partially or completely offset the force on the leading edge of the backing plate **115** created by the rotor **130**, thereby potentially avoiding the uneven distribution of the braking force and, hence, the uneven wear of the inner brake pad **110**. This and other features will be discussed in more detail below.

Turning again to the drawings, FIGS. **2**A, **2**B, and **2**C are side, top, and bottom views, respectively, of the tappet **200** of this embodiment. The tappet **200** comprises a portion that is configured to couple the tappet **200** with a support member. For example, FIGS. **2**A and **2**B show the threaded tube **210** coupled with mating threads in an interior of a coupling member **205** of the tappet **200**. Alternatively, the threaded tube **210** can be coupled to the tappet **200** by crimping a portion of the body of the tappet **200** to the threaded tube **210** with an intermediary bushing (not shown). Other affixation methods are contemplated. (While a threaded tube **210** is shown in this example, it should be understood that other types of support members can be used (e.g., a non-threaded tube, a rod, etc.) FIG. **2**C indicates a center **230** of the tappet **200**, which as will be discussed below, can be positioned to align with the center **117** of the backing plate **115** (see FIG. **3**A). As shown in FIG. **2**B, in this embodiment, the top surface **220** of the tappet **200** is flat. In other embodiments, the top surface **220** of the tappet **200** can have raised portions and/or recessed portions that can mate with mating portions on the backing plate **115**, as will be discussed below. This would create a unique interface, such that the backing plate **115** would be keyed with a matching tappet **200**, and vice versa. As will be discussed in more detail below, the top surface **220** of the tappet **200** in this embodiment is tapered/angled. As such, as shown in FIG. **2**C, when the top surface **220** of the tappet **200** rests upon a flat surface, the coupling member **205** is located at a slight angle with respect to that flat surface.

FIG. **3**A is an illustration of the backing plate **115** of this embodiment. The overall shape of the backing plate **115** shown in FIG. **3**A is just an example, and other shapes (some of which are illustrated in other drawings herein) can be used. The side of the backing plate **115** shown in FIG. **3**A is the side that contacts the top surface **220** of the tappet **200** (see FIG. **3**B), and the opposite site of the backing plate **115** is bonded or otherwise coupled with the inner brake pad **110**. As shown in FIG. **3**A, the side surface of the backing plate **115** has a recess whose surrounding raised features **116** generally match the overall shape of the top surface **220** of the tappet **200**. So, as shown in FIG. **3**B, when the tappet **200** is pushed against the backing plate **115**, the tappet **200** is received in the recess and generally mates with the backing plate **115**. This coupling can help the backing plate **115** resist any rotation caused by the rotor **130** when it makes contact with the inner brake pad **110**, as well as key the use of the backing plate **115** and tappet **200** together. As shown in FIGS. **3**A and **3**B, in this embodiment, the center **230** of the tappet **200** is positioned to generally align with the center **117** of the backing plate **115**. In other embodiments, the tappet **200** is positioned such that its center **117** is offset with respect to the center **117** of the backing plate **115**. Also, as with FIG. **2**C, FIG. **3**B shows that the coupling member **205** is located at a slight angle with respect to the flat surface of the backing plate **115** because of the tapered/angled nature of the top surface **220** of the tappet **200** in this embodiment.

Turning now to FIG. **4**A, in a non-tapered-tappet design, the axis **400** that is perpendicular to the axis **410** running through the center **230** of the tappet **200** is co-linear with the axis **405** defined by the top surface **220** of the tappet **200**. In contrast, as shown in FIG. **4**B, in the tapered-tappet design, the tappet **200** is machined such that the top surface **220** of the tappet **200** is angled with respect to the perpendicular axis **400**. (Instead of being machined, a separate tapered piece can be secured to an existing flat-surface tappet.) In FIG. **4**B, that angle is one degree (exaggerated in FIG. **4**B to bring attention to the tilt). One degree of taper may be able to offset two millimeters for wear, for example. However, it is important to note that any suitable angle can be used. Also, the degree of the angle can be a function of the friction material used for the inner brake pad **110**. For example, a relatively-large angle might be used for a relatively-more-forgiving friction material.

As noted above, since the backing plate **115** is positioned generally parallel to the axis **400**, the top surface **220** of the tappet **200** is also titled with respect to the backing plate **115**. The tapered tappet **200** (see FIG. **4**A) can be used to bias the force that the tappet **200** presents to the backing plate **115** toward one side, which can partially or completely offset the unequal force distribution caused by the moment created between the brake pad drag force and abutment force that can lead to an uneven distribution of the braking force and uneven wear of the brake pad **110**. This is illustrated in FIGS. **5**A-**5**C.

FIG. **5**A shows the tappet **200** prior to contact with the backing plate **115**. As shown in FIG. **5**A, the tappet **200** is angled downward with respect to a perpendicular to the axis **410** running through the center **230** of the tappet **200**, as well as the axis **415** running through the center of the threaded tube **210**. This results in one end **500** of the tappet **200** being closer to the backing plate **115** than the other end **510** of the tappet **200**. As such, when the tappet **200** is pushed into the backing plate **115**, the protruding end **500** of the tappet **200** (but not the other end **510**) makes initial contact with the backing plate **115** (see FIG. **5**B).

As the tappet **200** is continued to be pushed into the backing plate **115**, the entire full front surface **220** of the tappet **200** comes into contact with the backing plate **115** (see FIG. **5**C). So, both the protruding end **500** and the other end **510** of the tappet **200** push against the backing plate **115**. However, as noted above, because of the tilt in the top surface **220** of the tappet **200**, the threaded tube **210** becomes slightly angled, so there is a slight angle between the axis **410** running through the center **230** of the tappet **200** and the axis **415** running through the center of the threaded tube **210**. So, instead of the tappet **200** providing a normal force to the center **117** of the backing plate **115**, the protruding end **500** of the tappet **200** creates a biasing force on the trailing edge of the backing plate **115**. That is, even though the center **230** of the tappet **200** is aligned with the center **117** of the backing plate **115**, the center of pressure is biased away from the center **117** of the backing plate **115** toward the trailing edge of the backing plate **115** without moving the relative location of the center **230** of the tappet **200** toward the trailing edge of the backing plate **115**. This off-center force on the trailing edge of the backing plate **115** can partially or completely compensate for the force on the leading edge of the backing plate **115** created by the unequal force distribution caused by the moment created between the brake pad drag force and abutment force. This can avoid the problem noted above of uneven distribution of the braking force and, hence, uneven wear of the inner brake pad **110**.

Also, as noted above, the top surface **220** of the tappet **200** generally mates with the matching profile/recess formed in the backing plate **115**. This helps the backing plate **115** resist rotating due to the rotational forces being applied by the rotor **130**. This also provides a unique interface, such that the backing plate **115** would be keyed with a matching tappet **200**, and vice versa. As will be discussed below, other keyed shapes can be used. Further, the top surface **220** of the tappet **200** is generally elongated and covers a relatively-large area of the backing plate **115** in this embodiment, which can help distribute the braking force on the backing plate **115** to further assist in providing even distribution of the braking force and, hence, more even wear of the brake pad. It should be noted that the elongated shape of the tappet **200** shown in the above-referenced figures is merely an example and other shapes can be used, some of which are described below.

Also, in this embodiment, the overall shape of the top surface **220** of the tappet **200** is symmetrical. As shown in FIGS. **6**A and **6**B, this means that a 180-degree rotation of the tappet **200** moves the position of the protruding end **500** of the tappet **200** 180 degrees. This allows the tappet **200** to be used on backing plates positioned either on the left or right side of a wheel end. So, instead of manufacturing different configurations of tapered tappets (e.g., "left-hand tapered tappets" and "right-hand tapered tappets") for left or right sides of a wheel end, a single configuration can be used, with the tappet **200** being rotated such that the protruding end **500** is in the desired location. Once the tappet **200** is "clocked" in the desired position, the tappet **200** can be fixed in position by an anti-rotation device, such as with an elastomeric bellow (boot) positioned round the rear of the tappet **200** to seal against contaminants.

Not only does the use of such a "universal" tapered tappet reduce manufacturing complexity by requiring only a single tapper tappet design to be manufactured, it also eliminates the need to stock different types of tapered tappet for different uses. Further, the "universal" tapered tappet avoids the possibility of installing the wrong type of tappet at a given wheel end. This also provides an advantage over an alternative embodiment where the backing plate is tapered and the tappet is flat, as a tapered backing plate can only be used on certain wheel ends and is not universal.

There are many alternatives that can be used with these embodiments. For example, as noted above, the shapes of the tappet **200** and the backing plate **115** can vary, as can the features on the tappet **200** and backing plate **115** used to key/register the tappet **200** and backing plate **115** (the keying/registering feature does not need to be used). Also, while a tapered tappet **200** was described with a single piston design, multiple tapered tappets can be used on a multi-piston braking system (e.g., two tapered tappets can be used in a two-tappet system) and, as discussed below, on a single piston with features that mimic multiple tappets. Further, while a centered piston system is discussed above, it should be understood that a tapered tappet can be used in a system where the piston is off-center with respect to the center of the backing plate.

Other embodiments and variations can be used, such as the ones discussed below, for example

Examples of Tappets and Brake Pad Backing Plates with Interface Features

In the example tappet **200** and backing plate **115** discussed above, the top surface **220** of the tappet **200** generally mated with a matching profile/recess formed in the backing plate **115**. This provided a uniquely-shaped interface, with a certain design of the backing plate **115** being keyed to a certain design of the tappet **200**. In addition to possibly providing resistance to the forces being applied by the rotor **130** as it rotates, this unique interface feature can ensure that only authorized backing plates are used with a given tappet, or vice versa (e.g., to prevent competitors from producing an aftermarket brake pad that works with a certain braking system (non-mating backing plates may not work properly)). Further, depending on the design, the interface feature can also serve as a guide to install a brake pad/backing plate into place in the braking system, as will be discussed below.

Instead of or in addition to using a matching profile/recess interface as in the above examples, the backing plate **115** can have one or more raised surfaces **750** that mate with a corresponding one or more recesses **760** in the top surface **220** of the tappet **200** (see FIGS. **7**A and **7**B). Many alternatives are possible. For example, instead of the raised surface **750** being on the backing plate **115** and the recess **760** being in the tappet **200**, the raised surface can be on the tappet **200**, and the recess can be on the backing plate **115**. As another alternative, multiple recess/raised surface pairs can be used. In some embodiments, all of the recesses are on the backing plate (or the tappet), and all of the raised surfaces are on the tappet (or backing plate). In another embodiment, both the backing plate and the tappet have recesses and raised surfaces. Also, as mentioned above, instead of or in addition to raised surfaces or recesses on the top surface **220** of the tappet **200** acting as an interface, the entire outer shape of the tappet **200** can serve as an interface, as in FIGS. **3**B and **7**A.

Many different configurations of tappets, backing plates, and interfaces are possible. The following paragraphs provide some example configurations. It should be understood that these are merely examples and that other types of configurations can be used.

Returning to the drawings, FIG. **8**A is an illustration of a backing plate **815** of another embodiment. As can be seen by a comparison with the backing plate **115** shown in FIG. **3**A, the backing plate **815** of this embodiment has a different overall shape (perimeter). Also, this backing plate **815** is configured for use with a single, circular tappet **800** (see FIGS. **8**B and **8**C) and has a circular recess **840** to receive the perimeter of the single, circular tappet **800**. This is in contrast to the design in FIG. **3**A, where the tappet **200** was a generally-oval shape that contacted more of the surface of the backing plate **115**. As shown in FIGS. **8**A, **8**B, and **8**C, in this embodiment, in addition to the interface features of a circular recess **840** in the backing plate **815** matching the circular shape of the tappet **800**, the backing plate **815** contains a raised portion **850** that mates with a recess **860** in the tappet **800**. This unique interface feature can ensure that only brake pad backing plates with matching features can be used with the tappet **800**. This may also provide resistance to rotation. Further, this interface feature can serve as a guide to install the backing plate **815** into place in the braking system by sliding the raised surface **850** on the backing plate **815** into the recess **860** in the tappet **800**, as will be discussed below.

In the example tappet **800** shown in FIGS. **8**B and **8**C, the top surface of the tappet **800** has a taper to provide the counterforce discussed above. However, it should be noted that the unique mating interface feature can be used without the taper feature. For example, as shown in FIG. **8**D, the tappet **800** can have a non-tapered top surface, such that the portions **810**, **820** of the tappet **800** on either side of the recess **860** have the same height. As another alternative (see FIG. **8**E), the portions **810**, **820** of the tappet **800** on either side of the recess **860** can have different, non-tapered heights, which, similar to the tapered design, may provide the counterforce discussed above.

Of course, many alternatives are possible. For example, as shown in FIGS. **9**A and **9**B, instead of the recess/raised surface **950**, **960** being at the center of the brake pad backing plate **915** and tappet **900**, the recess/raised surface **950**, **960** can be off-center. Also, as shown in FIGS. **10**A and **10**B, instead of the recess being in the tappet and the raised surface being on the backing plate, the opposite configuration can be used, where the recess **1060** is in the backing plate **1015** and the raised surface **1050** is on the tappet **1000**. Many other configurations are possible. For example, as noted above, the backing plate and the tappet can each have both recesses and raised surfaces in the same or varying shapes and sizes. Also, while the tappets **900**, **1000** in FIGS. **9**A, **9**B, **10**A, and **10**B are tapered, as noted above, non-tapered tappets can be used.

As also noted above, the interface features can serve as a guide to install the backing plate into place in a braking system. This will now be discussed in conjunction with FIGS. **10**C-**10**E. FIG. **10**C is an illustration of the brake pad backing plate **1015** prior to its installation in the braking system. As shown in FIG. **10**D, to install the inner brake pad **1010** and brake pad backing plate **1015**, the brake pad backing plate **1015** is positioned such that the recess **1060** in the brake pad backing plate **1015** can slide over the raised surface **1050** of the tappet **1000**. FIG. **10**E shows the inner brake pad **1010** and brake pad backing plate **1015** fully installed. FIG. **10**E also shows the outer brake pad **1020** and its backing plate **1025**, as well as the rotor **1030**.

Returning to the drawings, FIGS. **11**A and **11**B illustrate another configuration of a tappet **1100**. This drawing allows shows a cover plate **1105**, the return springs **180**, and the bridge **175**, although other configurations and components can be used. As shown in these drawings, the tappet **1100** is tapered, although, as noted above, a non-tapered design can be used. Also, instead of the recess being a rectangular shape, the recess in this example is a combination of a rectangular shape **1160** with a half-circle shape **1161**, which would mate with an opposing protruding shape on the backing plate. These drawings also show that this tappet **1100**, as with at least some of the tappets discussed above, can be rotated 180 degrees about its center axis **1162** and oriented into the caliper during assembly to position the plunger accordingly to provide universality.

Again, many different shapes and sizes of the recess(es)/raised surface(s) can be used. For example, the backing plate **1215** shown in FIGS. **12**A and **12**B has both a recessed circular portion **1240** for receiving a tappet with a circular outer shape, as well a raised surface with a triangular "wedge" shape **1250** that would mate with a corresponding recess in the tappet. As another example, the backing plate **1315** shown in FIGS. **13**A and **13**B has both a recessed circular portion **1340** for receiving a tappet with a circular outer shape, as well a raised surface with curved trapezoidal-type shape **1350** that would mate with a corresponding recess in the tappet. The shape can be any arbitrary shape or can have some significance, such as a logo of a manufacturer of the brake pad/backing plate and tappet. Also, interface features can be shaped or placed on the backing plate to supplement the strength of the backing plate in critical areas, such as the center of the backing plate.

As noted above, many alternatives are possible, such as the position of the recess/raised surface (e.g., male or female features (debossed or embossed)) being juxtaposed between the backing plate and the tappet, as well as the backing plate and tappet containing both recesses and raised surfaces. Further, the interface features do not have to be on the entire length of the tappet or backing plate. As also noted above, the top surface of the tappet can be tapered, non-tapered, and/or have portions with uniform or non-uniform heights. Also, these embodiments can be used alone or in combination with the embodiments discussed above and/or below.

Again, many different shapes and sizes of the recess(es)/raised surface(s) can be used. For example, the backing plate **1350** shown in FIG. **14**A has both a recessed circular portion for receiving a tappet with a circular outer shape (perimeter), as well as a raised surface with a horizonal feature **1362** that would mate with a corresponding recess in the tappet. More specifically, in FIG. **14**A, the single horizontal feature **1362** tapers up towards the right. This can be used, for example, on a brake where the inboard pad is oriented such that the pad will travel away from the upwards taper. In this case, the pad will move to the left so as not to self-lock into the groove/onto the taper. Note, this can make the pad "handed." Also, to address tapered wear, the tappet face can have an angle to it.

As another configuration, the backing plate **1370** shown in FIG. **14**B has a single horizontal feature **1372** that tapers up towards the left. This can be used on a brake where the inboard pad is oriented such that the pad will travel away from the upwards taper. In this case, the pad will move to the right so as not to self-lock into the groove/onto the taper. Note, this would make the pad "handed" (in the opposite way as FIG. **14**A). Also, to address tapered wear, the tappet face can have an angle to it.

So, in FIGS. **14**A and **14**B, the triangular "wedge" shapes **1362**, **1372** are oriented horizontally (not vertically). The orientation is such that it may help prevent contact and/or a locking of the wedge shapes **1362**, **1372** between the brake pad backing plate interface feature (wedges) and tappet interface feature (wedge) during braking, as compared to a vertical arrangement.

In yet another configuration, two horizontally oriented wedge shapes are used that would mate with a corresponding recess in the tappet with similar features. The shape can be a tapered angle or wedge shape, or two mated tapered angles or wedges oriented with the tapers away from or towards one another. Such shapes may also serve to prevent a contact and potential locking between the tappet feature and the backing plate feature as the backing plate slides towards or away from it during braking.

More specifically, in FIG. **14**C, the backing plate **1380** has a groove design **1382** where the features are tall on each end and taper in towards the center. The tappet can be angled and keyed into this shape. Note, this style may or may not tend to self-lock if the pad shifts to the right or left. This would not be a handed pad. In FIG. **14**D, the backing plate **1390** has a groove design **1392** where the features are short on each end and taper up towards the center. The tappet can be angled and keyed into this shape. Note, this style may or may not tend to self-lock if the pad shifts to the right or left. This would also not be a handed pad.

Examples of Single Air Disc Brake Tappets with Features That Mimic Multiple Tappets

As noted above, to reduce cost and complexity, a single tappet can be used. However, unlike a two-tappet brake which distributes braking force over left- and right-sides of the backing plate, the tappet in a single-tappet brake can contact a smaller surface of the backing plate. So, as compared to using a two-tappet brake, using a single-tappet brake can result in an uneven distribution of braking force and, hence, uneven wear of the inner brake pad. More specifically, at the rotor rotates, the leading edge of the inner brake pad can see more application pressure on it due to the unequal force distribution caused by the moment created between the brake pad drag force and abutment force, thereby causing the leading edge of the inner brake pad to wear faster than the trailing edge of the inner brake pad. The tapered tappet designs in the above embodiments can be used to partially or completely counteract this force to address this problem.

In another embodiment (see FIGS. **15**A and **15**B), a single tappet **1500** is used with raised features **1510**, **1520** on a plate **1505** that mimic multiple tappets. (In one embodiment, the distance between centers of the raised features **1510**, **1520** is about 131 mm, although any suitable distance can be used.) This provides a "best of both worlds" design, as the single tappet **1500** reduces the cost and complexity with respect to a two-tappet system, while the raised features **1510**, **1520** provide at least some, if not all, of the force-distribution benefits of a two-tappet system. These raised features **1510**, **1520** can distribute the force on a backing plate, which can prevent bending or damage to the backing plate and brake pad, thereby avoiding a possible need to create a very thick or strong (and consequently heavy) backing plate that resists bending or damage. In another embodiment (shown in FIGS. **15**C and **15**D), two tappets **1512**, **1514** are used. However, unlike prior two-tapped designs, the outer shape (perimeter) of the two tappets are keyed to at least part of the shape of the recesses **1410**, **1420** in the backing plate. The various configurations and options (e.g., sizes and shapes of the tappets, how the tappets fully or partially mate with the recesses, using (or not using) a taper, etc.) can be applied to this alternative as well.

These embodiments can be used alone or in combination with the interface features and/or tapered design discussed above. For example, in the embodiment shown in FIGS. **15**A and **15**B, the raised features **1510**, **1520** are circular in shape and mate with corresponding recesses **1410**, **1420** in the backing plate (the female recesses **1410**, **1420** in the backing plate **1415** can also be used to receive male tappets in a two-tappet braking system).

Also, as shown in FIG. **16**A, the overall shape of the top of the tappet **1500** can be symmetrical, so a 180-degree rotation of the tappet **1500** can move the position of the raised features **1510**, **1520** to the opposite side of the backing plate **1415** to provide the universality advantages discussed above (e.g., the tappet **1500** can be used on both left- and right-handed brakes). (FIG. **15**A also shows that the plate **1505** in this embodiment has various reinforcement ribs and features to stiffen and prevent distortion of the plate **1505**, as well as the inner brake pad backing plate **1415**.) However, in another embodiment (shown in FIGS. **16**E and **16**F, instead of the raised features being symmetrical, the raised features **2380**, **2390** are offset by different distances from the center **2392** of the tappet **2394**. In this example, the threaded tube is offset from the center **2392** of the tappet **2394**, while, in other examples, the threaded tube is the center **2392** of the tappet **2394**.

Turning back to FIG. **16**B, the raised features **1510**, **1520** can have different, but uniform heights, with one raised feature **1510** being higher than the other raised feature **1520** (e.g., by five millimeters). If each of the recesses **1410**, **1420** in the backing plate **1415** have the same depth, the raised feature **1510** with the greater height would contact the backing plate **1415** before the other raised feature **1520**. This can provide a tilting action (similar to in the tapered design discussed above) to provide a counteracting force to the force created by the unequal force distribution caused by the moment created between the brake pad drag force and abutment force that can cause uneven wear of the brake pad (e.g., by shifting the pressure point (offset towards the trailing edge) to control tapered pad wear). Alternatively, each recess **1410**, **1420** in the backing plate **1415** can have different depths to account for the different heights of the raised features **1510**, **1520**, which would provide an additional dimension to the keying interface feature. Further, in another embodiment (see FIG. **16**D) both raised features **1510**, **1520** are tapered.

In another embodiment (shown in FIG. **16**C), at least one of the raised features (here, raised feature **1510**) can be tapered. In other embodiment, both of the raised features **1510**, **1520** are tapered at the same or different angles (e.g., the two raised features **1510**, **1520** can be angled with respect to each other.

Many alternatives are possible. For example, in FIG. **17**A, the tappet **1700** has raised features **1710**, **1720** on a plate **1705** of the tappet **1700**, but the shape of the raised features **1710**, **1720** is an octagon instead of a circle (the mating shapes **1610**, **1620** on the backing plate **1615** are also octagon shaped). In yet another embodiment, the raised features and matching recesses are different geometric shapes. For example, in FIG. **17**B, the tappet **1900** has an octagonal-shaped raised feature **1910** and a circular-shaped raised feature **1920** on its plate **1922** that match with corresponding shapes **1810**, **1820** on the backing plate **1815**.

Also, as shown in FIGS. **18**A and **18**B, the recess **2025** in the backing plate **2015** does not necessarily need to exactly match the geometric shapes of the raised features **2110**, **2120** on the plate **2105** of the tappet **2100**. In the example shown in FIGS. **18**A and **18**B, the recess **2025** in the backing plate **2015** is large oval that contacts the left 180-degree portion of the left raised feature **2110** and the right 180-degree portion of the right raised feature **2120**.

In yet another alternative, instead of the raised features being solid shapes, other shapes can be used. For example, in the tappet **2200** shown in FIG. **19**A, the two raised features **2210**, **2220** on the plate **2205** are rings instead of solid circles/discs. As another example, in the tappet **2300** shown in FIG. **19**B, the raised features **2310**-**2326** are arcs of rings instead of instead of continuous rings. Of course, there are merely examples, and other configurations can be used.

CONCLUSION

It should be understood that all of the embodiments provided in this Detailed Description are merely examples and other implementations can be used. For example, some features describing the interface between the tappet or tappet plate can be used in either a single tappet air disc brake or multiple tappet air disc brake. Accordingly, none of the components, architectures, or other details presented herein should be read into the claims unless expressly recited therein. Further, it should be understood that components shown or described as being “coupled with” (or “in communication with”) one another can be directly coupled with (or in communication with) one another or indirectly coupled with (in communication with) one another through one or more components, which may or may not be shown or described herein. Additionally, “in response to” can be directly in response to or indirectly in response to. Also, terms such as “generally, “substantially,” or “about” can refer to a characteristic, parameter, or value that need not be exactly achieved, as deviations or variations (e.g., tolerances, measurement error, measurement accuracy limitations, etc.) may occur in amounts that do not preclude the effect the characteristic, parameter, or value was intended to provide.

It is intended that the foregoing detailed description be understood as an illustration of selected forms that the invention can take and not as a definition of the invention. It is only the following claims, including all equivalents, which are intended to define the scope of the claimed invention. Accordingly, none of the components, architectures, or other details presented herein should be read into the claims unless expressly recited therein. Finally, it should be noted that any aspect of any of the embodiments described herein can be used alone or in combination with one another.

What is claimed is:

1. An air disc brake tappet comprising:
a portion configured to couple the air disc brake tappet with a support member; and
a plate coupled with the portion;
wherein:
the plate comprises a plurality of raised features that mimic a plurality of air disc brake tappets;
the plurality of raised features comprise different heights:
the plurality of raised features are positioned on the plate to contact at least one recessed feature of a brake pad backing plate; and
depth(s) of the at least one recessed feature are unmatched with the different heights of the plurality of raised features.

2. The air disc brake tappet of claim **1**, wherein the at least one feature of the brake pad backing plate comprises a plurality of features having a same shape as the plurality of raised features.

3. The air disc brake tappet of claim **1**, wherein the at least one recessed feature of the brake pad backing plate has a different shape from the plurality of raised features.

4. The air disc brake tappet of claim **1**, wherein the plurality of raised features comprise a same shape.

5. The air disc brake tappet of claim **1**, wherein the plurality of raised features comprises different shapes.

6. The air disc brake tappet of claim **1**, wherein at least one of the plurality of raised features comprises a solid shape.

7. The air disc brake tappet of claim **1**, wherein at least one of the plurality of raised features comprises a portion of a solid shape.

8. An air disc brake pad assembly comprising:
a friction material; and
a backing plate coupled with the friction material;
wherein:
the backing plate comprises at least one recess shaped and positioned to receive a plurality of raised features of an air disc brake tappet;
the plurality of raised features mimics a plurality of air disc brake tappets; and
at least one of the plurality of raised features is tapered at an angle that is unmatched by an angle of the backing plate.

9. The air disc brake pad assembly of claim **8**, wherein the at least one recess in the backing plate comprises a plurality of recesses, each having a same shape as the plurality of raised features.

10. The air disc brake pad assembly of claim **8**, wherein the at least one recess in the backing plate has a different shape from the plurality of raised features.

11. The air disc brake pad assembly of claim **8**, wherein the at least one recess in the backing plate comprises a plurality of recesses, each having a same depth.

12. The air disc brake pad assembly of claim **8**, wherein the at least one recess in the backing plate comprises a plurality of recesses, each having a different depth.

13. The air disc brake pad assembly of claim **8**, wherein the at least one recess in the backing plate comprises a plurality of recesses, each having a different shape.

14. The air disc brake pad assembly of claim **8**, wherein the at least one recess in the backing plate comprises a plurality of recesses, each having a same shape.

15. An air disc brake system comprising:
an air disc brake pad comprising:
a friction material; and
a backing plate coupled with the friction material, wherein the backing plate comprises at least one recess; and
an air disc brake tappet comprising:
a support member; and
a plate coupled with t support member;
wherein:
the plate comprises a plurality of raised features that mimic a plurality of air disc brake tappets; and
at least one of the plurality of raised features is either (i) tapered at an angle that is unmatched by an angle of the backing plate or (ii) has a different height with respect to another one of the plurality of raised features, such that the at least one of the plurality of raised features contacts the backing plate before the another one of the plurality of raised features contacts the backing plate, which tilts the backing plate to provide anti-wear protection for the friction material.

16. The air disc brake system of claim **15**, wherein the at least one of the plurality of raised features has a different height with respect to another one of the plurality of raised features.

17. The air disc brake system of claim **15**, wherein the at least one of the plurality of raised features is tapered at an angle that is unmatched by an angle of the backing plate.

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